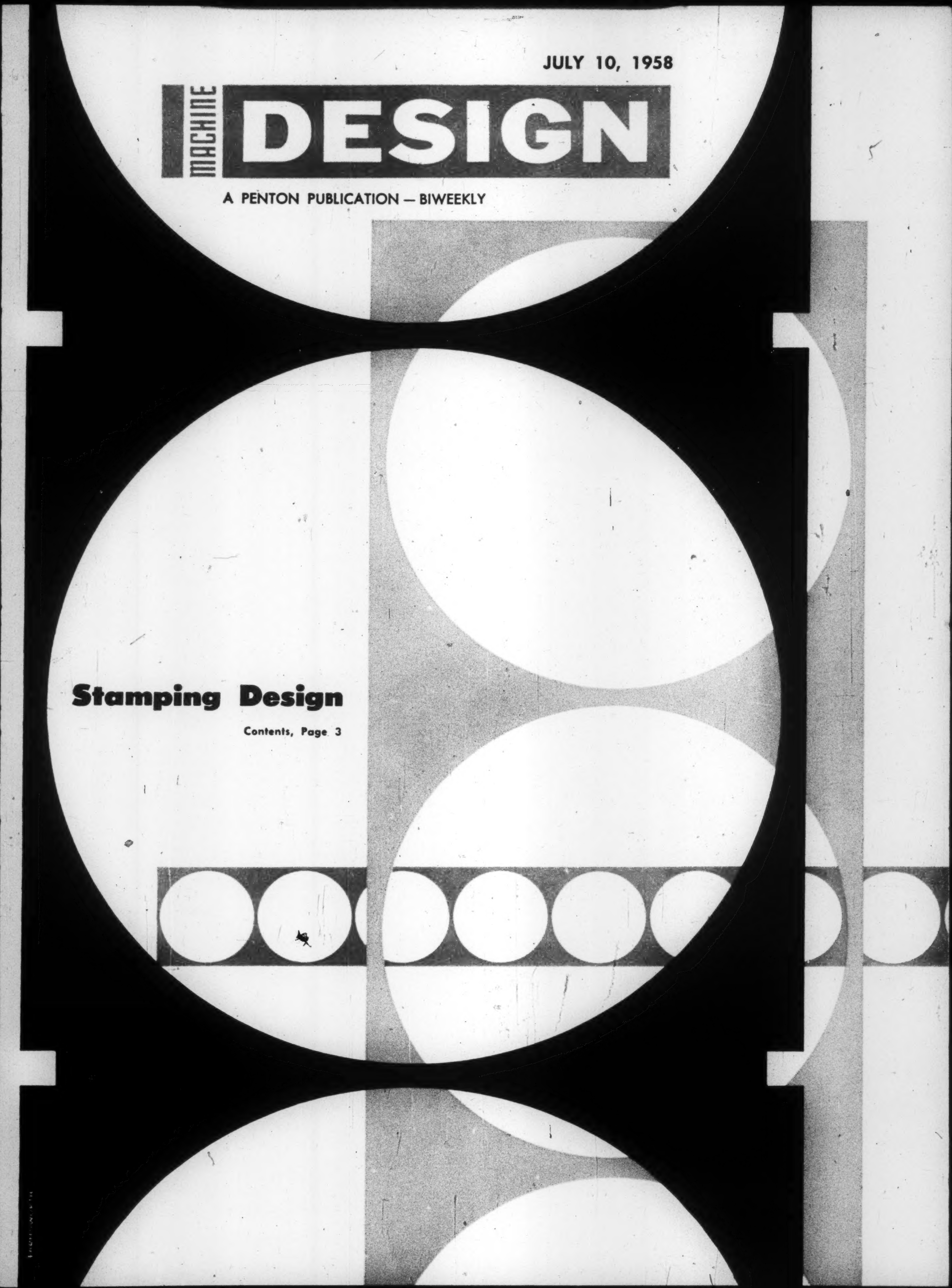
JULY 10, 1958

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Stamping Design

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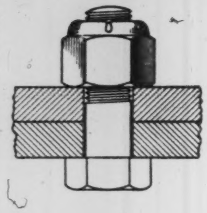
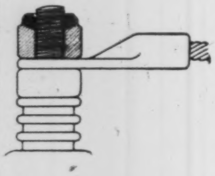
Ten fastening problems $olved by ELASTIC STOP nuts

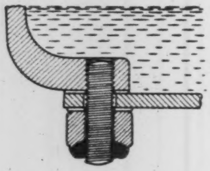
TIGHTENED AGAINST THE WORK



Vibration and impact proof bolted connections in standard applications.

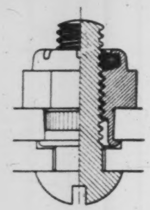


On all electrical terminals subjected to vibration in transit or operation, and for any electrical or electronic assembly where positive contact must be maintained.

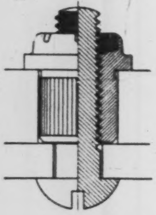


To seal bolt threads where leakage past stud threads must be prevented.

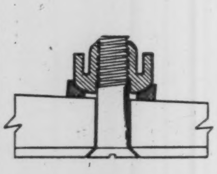
FOR MANY SPECIAL FUNCTIONS



Blind fastening applications where nut is "clinched" into sheet metal . . . becoming self-retaining as well as self-locking.

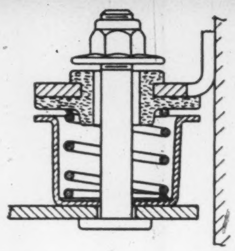


To eliminate drilling and tapping and provide steel thread strength for soft metals, an ESNA spline nut is pressed into a bored hole in casting.

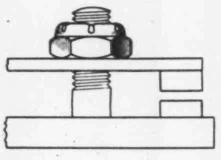


Simplified self-aligning self-locking fastener for bolting two non-parallel surfaces.

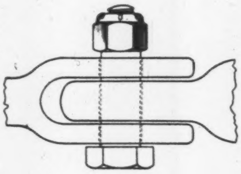
LOCKED ANYWHERE ON THE BOLT



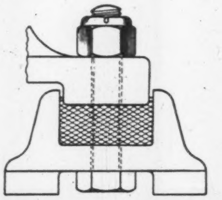
Spring-mounted connections or dynamic balancing, where nut must stay put yet be easily adjusted. (Flanged face eliminates need for extra washers.)



On make and break adjustment studs where accurate contact gaps must be maintained. Note "thin" height design for limited clearance.



For bolted connections requiring predetermined play.



For rubber-insulated and cushion mountings where the nut must not work up or down.

HOW THESE NUTS SOLVE SO MANY FASTENING PROBLEMS, ELIMINATING EXTRA PARTS AND OPERATIONS . . .

The red locking collar of an ELASTIC STOP® nut grips bolt threads with a perfect fit that will not loosen under severe vibration or stress reversals, and seals against liquid seepage. By bringing nut and bolt metal thread flanks into firm contact it eliminates wear producing axial play. The elastic locking action of the insert-type stop nut does not distort or gall bolt threads. It is reusable many times.

Send for the following free information: Elastic Stop nut bulletin; Rollpin® bulletin. Or enclose a drawing of your product for specific self-locking fastener recommendations. Write to Dept. N30-74.

Circle 401 on Page 19

ESNA

ELASTIC STOP NUT CORPORATION OF AMERICA
2330 VAUXHALL ROAD, UNION, NEW JERSEY

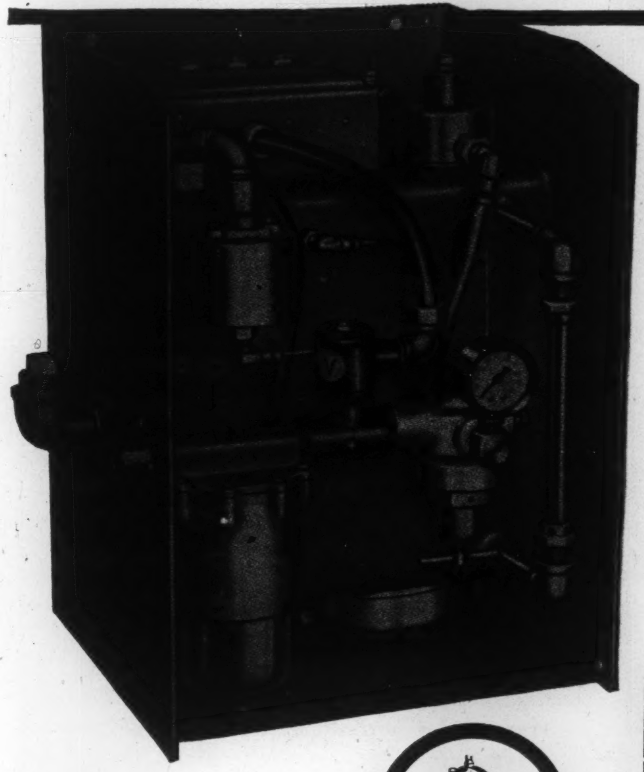
NOW! An Automatic Lubrication System with

300-500

bearing inch capacity

Oil-Mist Unit atomizes oil and distributes it
through tubing to all lubricated mechanisms.

oil-mist



provides safe–sure–continuous–foolproof lubrication!

✱ **Large Models Designed for Large Machines!** Designed to lubricate up to 500 Bearing inches. (1 Bearing Inch equals 1 inch of Shaft Diameter.)

✱ **Big Lubricant Supply!** 3-gallon capacity tank holds enough oil to provide a "48-hour week" of continuous lubrication for 500 Bearing Inches.

✱ **Extensive Coverage!** System is efficient in small, compact installation or extended over a distance of 480 feet.

✱ **Multiple Controls!** Automatic controls regulate air pressure, Oil-Mist delivery, check system operation and guard oil level.

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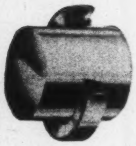
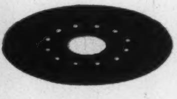
Circle 404 on Page 19

VALUE ANALYSIS where it really counts
. . . during design!



C/R Shaft Type Oil Seal

C/R Standard End Face Seal



C/R Sirvene Diaphragm

C/R Sirvis Molded Cup

C/R Rawhide Beveled Gear

Here's an expert at work, saving you money at the right time — during design. Like all C/R sales engineers, he's an experienced, well-trained representative whose knowledge springs from a solid engineering background. His ability to sit down with you during the design phase will help develop the most efficient and economical solutions to your problems.

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C/R
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RAWHIDE

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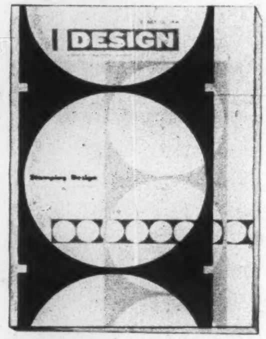

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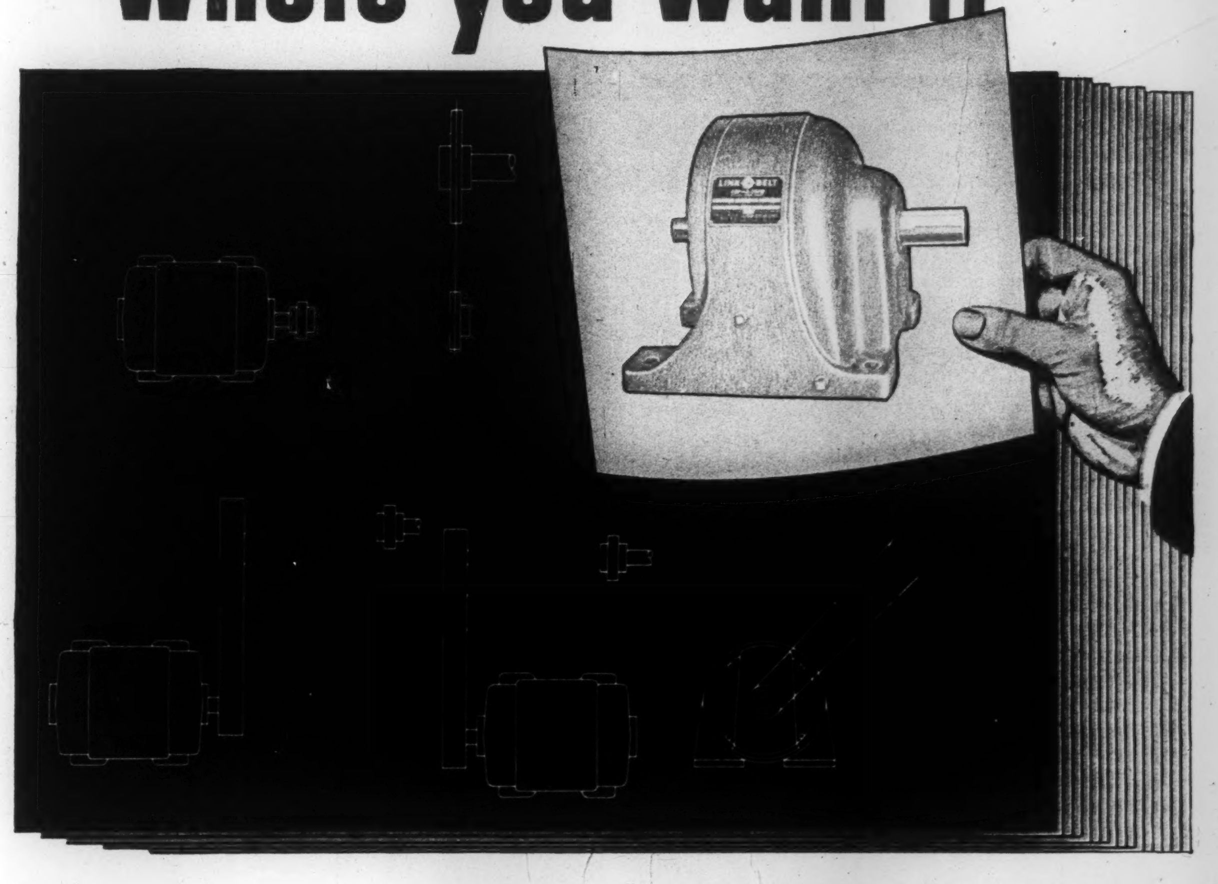
Here's a SPEED REDUCER that lets you

mount the motor where you want it



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Consists of a streamlined housing with double, triple or quadruple reductions up to 206 hp. Call your nearby Link-Belt office. Ask for Book 2651.

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MACHINE DESIGN

ENGINEERING NEWS

Fuel Processed at Sea In Seaway-Lakes Bulk Carriers

Oil-Purification System Converts Residual Oil to Fuel

MONTREAL—A 20,000-ton dry bulk carrier, the *Avery C. Adams,* like its sister ship, the *Alexander T. Wood,* will use low-cost bunker-type residual oil to power its diesel engine, which has a rating of 7200 hp at 125 rpm. The use of low-cost fuel on such large vessels for both cruising and maneuvering is credited to the installation of a Westfalia, high-capacity, centrifugal oil purification system. Design of this system permits the huge diesels to maintain optimum speed-power ratio at all times, thus eliminating use of high-cost diesel fuel for maneuvering.

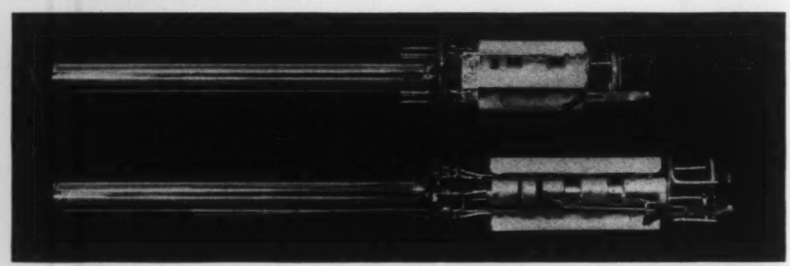
Conversion of the residual oils to fuel is achieved by a team of centrifugal purifiers and clarifiers. Seven centrifugal separators process the highly viscous bunker-type oil as fuel for the ship's main engine, purify the lubricating oils, and supply diesel oil for an auxiliary engine.

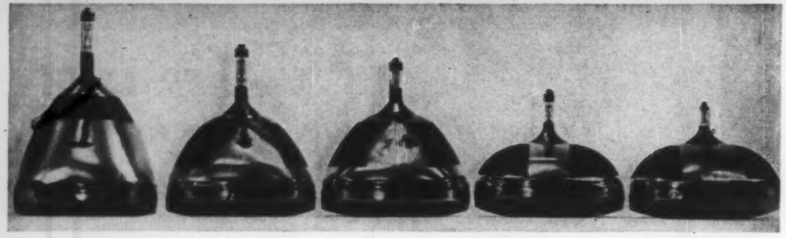
In processing the viscous residual oil, two purifier-clarifier sets are used. After the oil passes through the desludger, a clarifier completes the processing. Each set handles 400-500 gal per hr of residual oil with a viscosity of 5000 SSU at 100 F.

Another economy feature on the *Avery C. Adams* is the provision for re-use of lube oils from the diesel engines. Dirt and water are removed from lube oils by two oil separators, each of which consists of a centrifuge, motor, two pumps, a heater, and a control panel. One of the two pumps in the unit draws the oil in and feeds it into a thermostatically controlled electric heater, where it is heated to obtain proper viscosity for efficient purification. Passing through a temperature check point, the oil is then fed into the centrifuge where solids and water are removed. The second pump recirculates the oil to the diesel-engine lubricating system.

Shorter Tube, New Chassis Shrinks Size of TV Sets

TV ON A PEDESTAL, with a swiveling screen, is a new concept introduced by Philco Corp. in its new Predicta series for 1959. Another innovation is a separate-screen model, in which cabinet and screen are connected by a 25-ft cord. The new sets are designed around a flat 21-in., 110-deg picture tube said to be 2 in. thinner than any currently in use. Chassis, also redesigned, is 6 in. deep and 8 in. high compared to 16 x 18 in. last year. Thinner tube results from redesigned electron gun; grid-cathode-heater assembly is flat, rather than long and cylindrical. Photos, below, compare size of the new gun with one used in conventional 110-deg tube, and also show evolution of Philco tubes from the old 90-deg model to the '59 thin design.



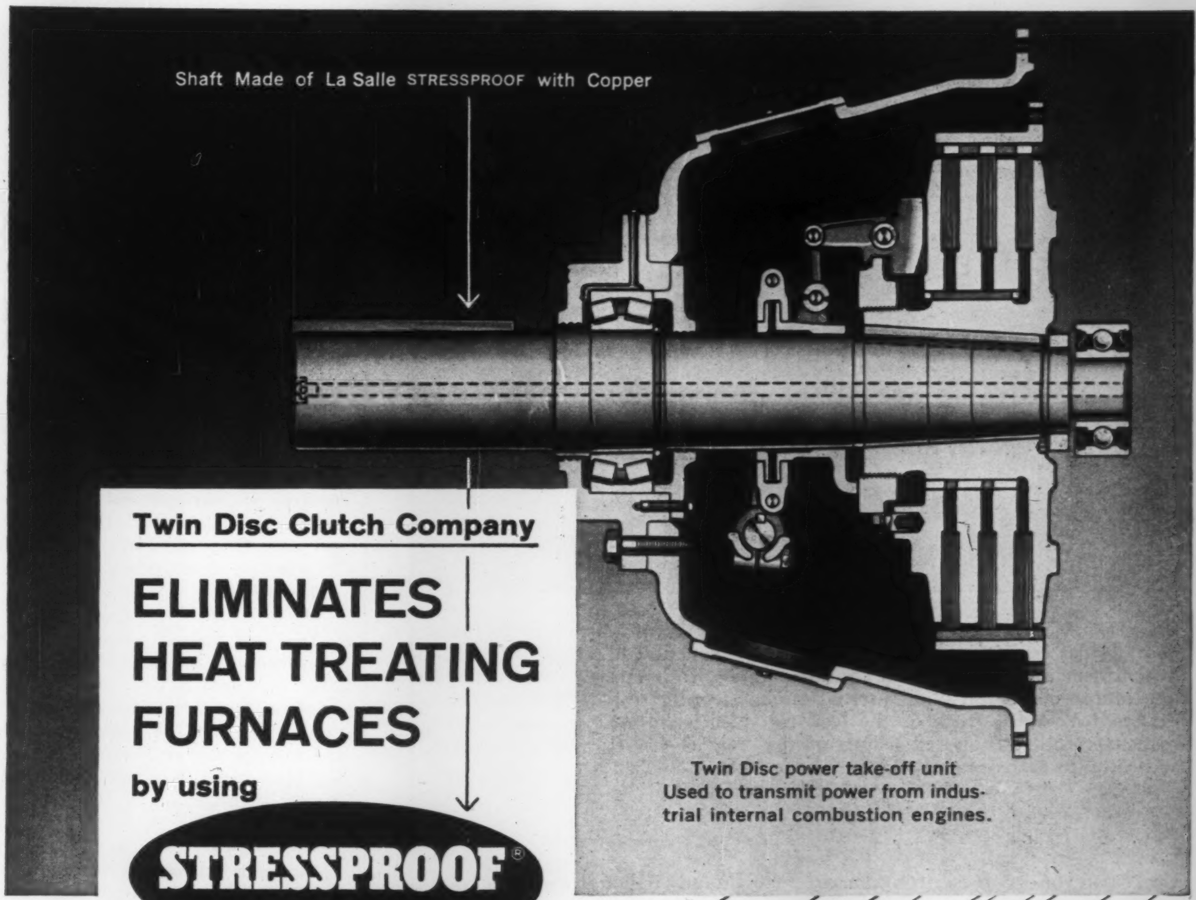


First Step for Engineering Unity: Re-Name Engineers Joint Council

Need, Ways, and Means Cited By ASCE's Lockwood

PORTLAND, ORE.—Another call for unity in the engineering profession, one that would start by changing the name of Engineers Joint Council to American Engineering Association, is sounded by Mason G. Lockwood, past president of American Society of Civil Engineers. According to Lockwood, the need persists for a single "voice" to represent the nation's half-million engineers, and a new name would attain more popular recognition.

To reach the elusive goal of unity,



Shaft Made of La Salle STRESSPROOF with Copper

Twin Disc power take-off unit
Used to transmit power from industrial internal combustion engines.

Twin Disc Clutch Company

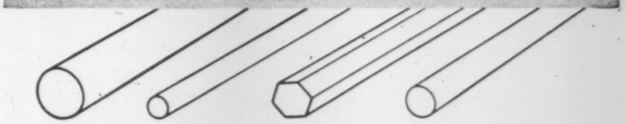
ELIMINATES HEAT TREATING FURNACES

by using

STRESSPROOF®

with copper

STEEL BARS



In Racine, Wisconsin, Twin Disc Clutch Co. saved money on a plant addition by eliminating heat treating furnaces . . . and they continue to save on part costs by using a material which needs no heat treatment . . . STRESSPROOF.

On the strength of over 15 years' experience with STRESSPROOF, Twin Disc knew they could cut their costs by purchasing this material which has the necessary properties in the bar.

They produce about 150 different models of power take-off shafts . . . see cross-section drawing. These shafts must possess great toughness and have the strength to take heavy loads. They must resist wear at the journals. Because one end of each shaft must be machined to individual customer specifications, machinability is important. Warpage after machining cannot be tolerated.

STRESSPROOF with copper fills these requirements on all counts because it has these four qualities in the bar: (1) Strength without heat treating. (2) Machinability (copper further improves machinability). (3) Excellent resistance to wear. (4) Minimum warpage.

By using STRESSPROOF, Twin Disc eliminates the cost of heat treating, cleaning and straightening. Working conditions are better . . . the plant is cleaner and cooler, and floor space requirements are less. Time and money consuming production steps are eliminated.

Twin Disc gets better parts at lower cost, and perhaps you can profit by their experience. Unless you have investigated STRESSPROOF recently, you may be overlooking worthwhile savings, especially since copper has now been added to improve machinability.

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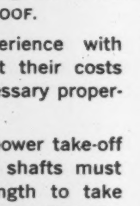

Please send literature describing La Salle STRESSPROOF with copper.

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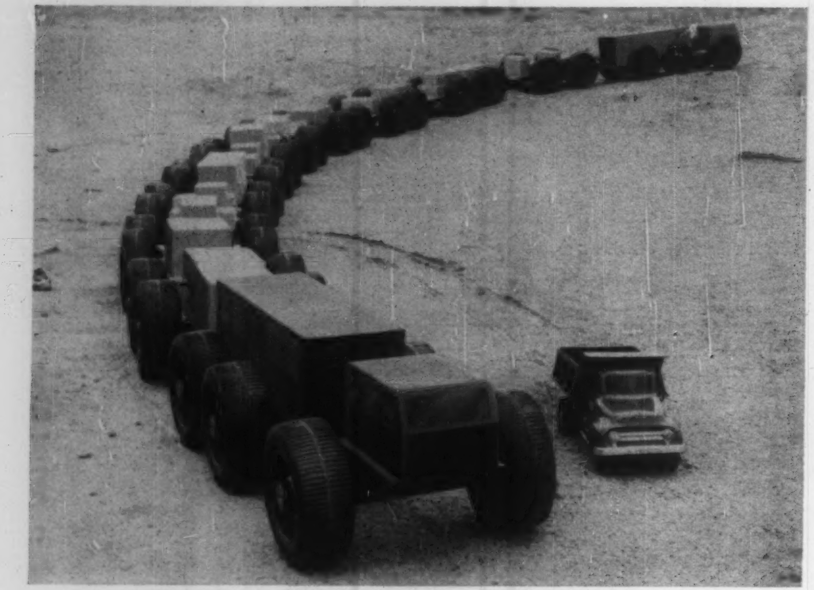


BIG, BUT NIMBLE, this 52-wheel trackless train (scale model shown here) is designed to use nuclear or conventional power, according to R. G. LeTourneau, Inc. Like all LeTourneau trains, it is electric-motor driven—one motor per wheel—and uses a unique steering system that compels all cars to follow the track of the lead car. Either-end steering provides high maneuverability. Proposed length of the train is 450 ft; width would vary according to user demands. Tire size: 4 x 10 ft.

Lockwood offers these recommendations:

- NSPE be persuaded to join Engineers Joint Council.
- Engineering Council for Professional Development, concerned primarily with accrediting colleges and maintaining educational standards, be merged with EJC.
- EJC be provided with sufficient funds to accomplish its co-ordinating mission. To raise funds, its supporting agencies would arrange to increase their per-member subscriptions 50 per cent each year for the next four budget years.

Lockwood cites the need for additional funds to overcome "two weaknesses in EJC." One is the nonrepresentative composition of the EJC board from a geographical standpoint. The remedy: Constituent societies should elect representatives who are geographically dispersed, and pay their travel expenses to board meetings.

The second weakness—EJC is not well enough known—requires that money be spent to establish an appropriate unity organization (American Engineering Association) and to finance regional meetings, officer and staff travel, and more public relations.

Basically, Lockwood's plan is similar to one sponsored recently by AIEE, which proposed that three of the top organizations join hands to represent engineers. Efforts were to be divided as follows:

- EJC—To co-ordinate all technical activities.
- ECPD — To co-ordinate all educational activities.
- NSPE—To co-ordinate all professional activities.

This setup, it was claimed, would eliminate duplication of activities in areas such as education, and would form a co-ordinated representative council for all engineers. A major stumbling block in the plan, however, was a proposal that EJC join NSPE. This drew heavy criticism.

Lockwood's unity plan calls for NSPE, a single organization, to join EJC, already a federation, as a more logical move. This, he says, would accelerate the growth of both organizations, and at the same time would decisively advance unity in the profession.

Topics

Seven-minute wiener roast is prepared by a new gadget that plugs into the cigarette lighter of an automobile. It cooks two hot dogs in horizontal tubes and warms two buns.

• • •

Chemise look invades the electric lamp industry with the introduction of a cylindrical "bulb" by Westinghouse. Interior of the new bulb has an electrostatic silica coating claimed to distribute light better than present frosted lamps; the cylindrical shape provides more surface for the coating than a conventional bulb of the same diameter.

• • •

Aluminum automobile engines—if used by all manufacturers—would require a billion pounds of this metal per year. On a unit basis, this would increase use of aluminum from 52 to 450 lb per car.

• • •

Ten bags full of grain are dried simultaneously by an "in-sack" grain dryer developed in Great Britain. The machine circulates warm air, ranging from 110 to 180 F, through filled sacks at the rate of 200 cfm. Depending upon moisture content, more than a ton of material can be dried in one to four hours.

• • •

Electronic sandman is housed in a small, portable aluminum box. The seven-transistor Sleepatron, powered by four flashlight batteries, reproduces the sound of falling rain, a sound which research indicates is conducive to putting people to sleep. The manufacturer, Gardiner Electronics Co., points out that the Sleepatron's simulated rainfall is also effective in drowning out noises that would disturb an office worker's or a student's concentration.

• • •

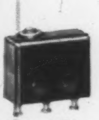
Mathematical-minded typewriter developed by a British company has two keyboards which are synchronized so that the symbols fall into place correctly on the script. The machine has a total of 180 keys.

• • •

Sniffed sub, sank same could be the report of an aircraft equipped with the Navy's odoriferous homing equipment, which literally scents a submarine. This "Sniffer Gear" locates submarines by tracking the contaminated atmosphere above and downwind of the snorkel. Air is ionized by exhaust gases, and sensitive electronic equipment in the aircraft picks up the scent. The Navy is now developing similar equipment to detect snorkelless atomic submarines by measuring the trails of radioactive seawater.

MICRO SWITCH Precision Switches

NEW


Actual Size

We've Miniaturized the Subminiature!

WEIGHT: *1 gram . . . 28 switches to the ounce . . . over 430 to the pound.* SIZE: *.500" long, .200" wide, .350" high.*
CUBIC CONTENT: *.035 cubic inches.* ELECTRICAL RATING: *5 amps-250 vac, 30 vdc. SPDT.*

After a long period of laboratory development, MICRO SWITCH announces this new, highly miniaturized precision snap-action switch and a complementary line of actuators.

We call it the "Sub-subminiature!"

This new "SX" basic switch represents an entirely new set of answers to the space-weight problems in dependable precision switching. It combines new small size with more than ample capacity for wide usefulness, meeting the pressing demand for miniaturization combined with reliability.

In its exacting development, many problems of design, testing and quality control presented themselves. However, 23 years of experience proved of immense value. As a result, a new standard has thus been set by which all precision switches must be measured.

This broad experience can prove of equal value to you. Send for more information about this new switch. Request Data Sheet No. 148.

—•—

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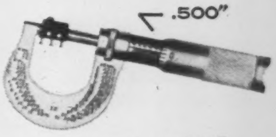

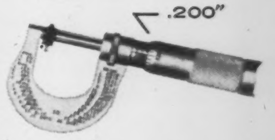

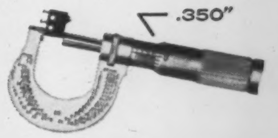

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Soviets Report Disintegration With Electrohydraulic Effect

Use Electric Discharge, Water, To Crumble Rock

WASHINGTON — In a laboratory of the Leningrad Polytechnic Institute, a middle-aged Russian scientist noiselessly breaks granite up into small pieces, as though it were an overripe watermelon, reports the Washington-published Soviet periodical *USSR*. The scientist, Lev Yutkin, reportedly makes use of a phenomenon known as the electrohydraulic effect.

He is said to have first come upon the effect while he was a student experimenting with high voltages. Placing both ends of a conductor in a vessel of water, he turned the power on. A spark leaped the gap between conductors, and the vessel shattered into bits.

Yutkin compares the electrohydraulic effect with the shattering of a water-filled barrel when a bullet is shot into the practically incompressible water. Similarly, when a liquid surrounding a spark discharge is acted upon by the "artificial lightning," liquid molecules fly off in all directions to create a hydraulic impact of enormous force. When the space, formed instantaneously in the liquid, collapses, the result is a second impact, termed a cavitation impact. The two impacts, compression and cavitation, create pressures which are immense, amounting to several hundred atmospheres, within the "lightning" zone.

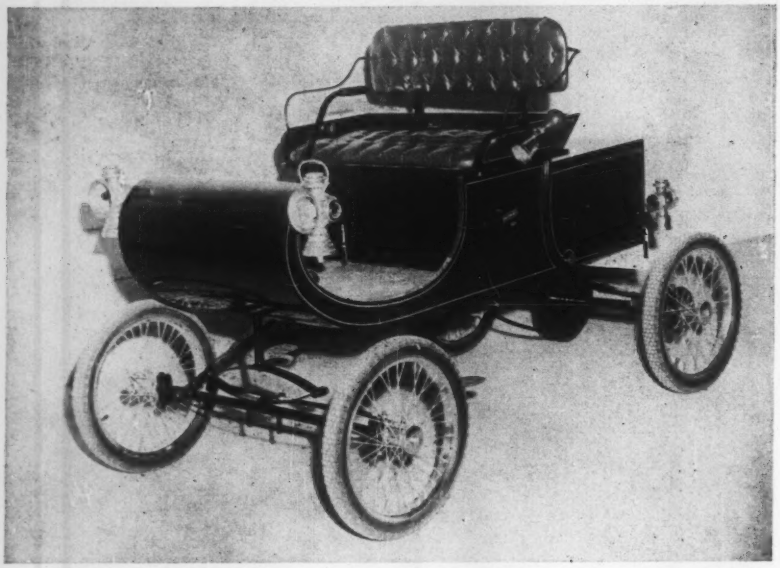
To demonstrate in his laboratory, Yutkin points to a vessel which looks much like a tin pail. He explains, "The action of this crusher is based on the principle of the cavitation impact." He places lumps of granite into the pail from the top, and a stream of pulp consisting of crushed granite and water flows continuously from the bottom of the pail.

The phenomenon is said to solve the problem of direct conversion of electrical into mechanical energy without electric engines or other machines at phenomenally high efficiency. Practical applications for the process are claimed to include crushers for the production of building materials, drilling for oil and gas wells, and sinking mine shafts of any diameter to any depth.

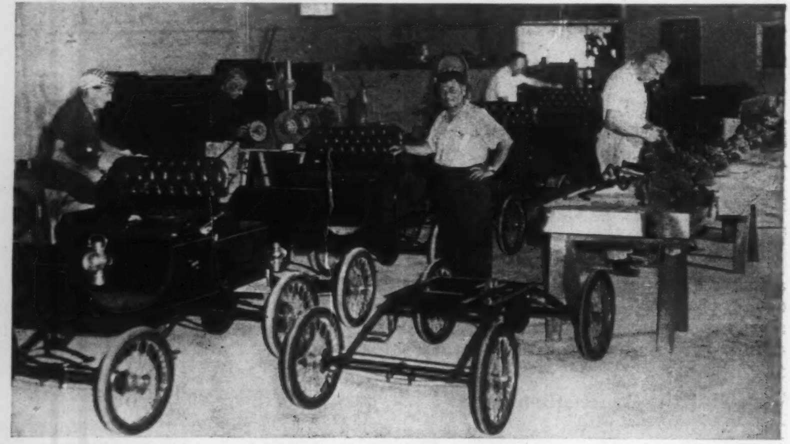
According to the report, a test model of an electrohydraulic drill—an inch and a half in diameter, powered with only 625 w—drills a hole in solid concrete at the astonishing speed of almost 50 ft per hr. Cost of drilling is claimed to be tens of times cheaper than the usual method, and the drill is said to last almost indefinitely.

In a pump, the electrohydraulic effect is said to produce a jet of water which can cut through wood. The Russians claim also that it will make possible the design of unusually powerful forging, embossing, and pressing machines. Also, they say, it can be used for machines to cut articles of rolled metal right in the rolling mills.

Rollsmobile: 1901-1958



CAR WITH THE BACKWARD LOOK is how Starts Mfg. Co. describes their two-thirds scale version of the 1901 Oldsmobile. Model changeover, from '01 to '58, includes a new Continental engine with automatic transmission, electric starter, stainless-steel sulky wheels with sealed ball bearings, and no reverse gear. "Interior" styling features a red leather seat with 60 red buttons and red nylon carpets. Exterior is black with gold striping. The new Rollsmobile travels 35 mph, carries two passengers, and gets 100 mpg. Price at the factory: $895. Production line, below, is geared to 50 cars per month.



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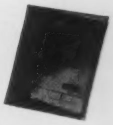

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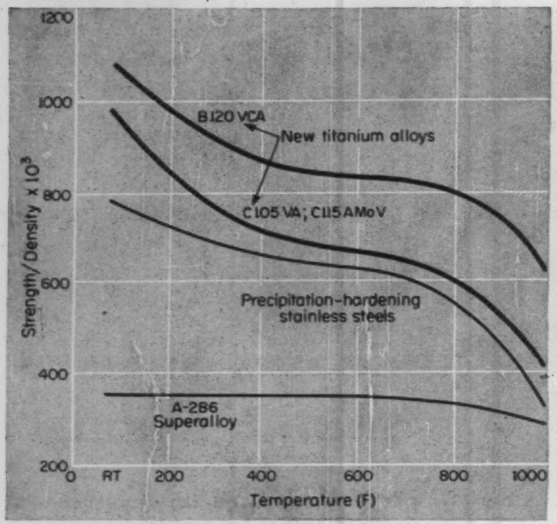
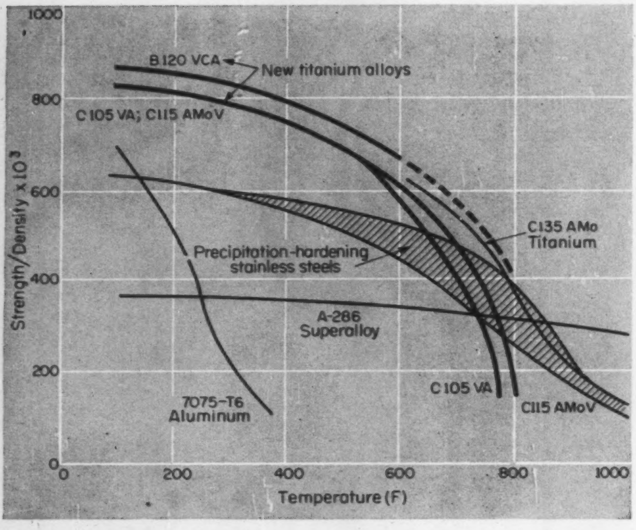


Highest strength-weight ratio . . .

. . . of any alloy in the world is shown by yield-strength comparison of new Crucible titanium alloys with precipitation-hardening stainless-steel and A-286 super-alloy. Normal tensile test strain rates of 2½ minutes to a 0.2 per cent offset were used.



Slower strain rates . . .

. . . still show the new titanium alloys to be superior to other materials to 600-800 F. Test was for 0.2 per cent plastic creep in 500 hr. New "formageable" titanium alloys are superseded at higher temperatures by older C135 AMo titanium alloy, precipitation-hardening stainless, and A-286 superalloy.

Strength Skyrockets in Formable Titanium

New "formageable" alloys heat treat to highest strength-weight ratio of any metal, yet are easily formed in annealed state.

PITTSBURGH—A major breakthrough in titanium alloys may put titanium on a competitive technical basis with stainless steel as a sheet and structural metal.

Three new alloys announced by Crucible Steel Co. of America have the highest strengths of any titanium-base sheet materials—yet can be easily formed. Strengths are startling: One alloy, B120 VCA, can be heat treated to 240,000 psi min tensile strength, with indications that tensile strengths approaching 260,000 psi may soon be possible. This alloy has three times the strength of pure titanium—and has the highest strength-weight ratio of any alloy in the world.

The new alloys are "formageable." Parts are formed while the alloys are in their soft, as-produced state, then thermally aged to high strength levels. Two of the new alloys, B120 VCA and C105 VA, can be welded with final strengths and ductilities equal to the parent metal. B120 VCA is cold-headable, the first high-strength alloy which can be processed by this method.

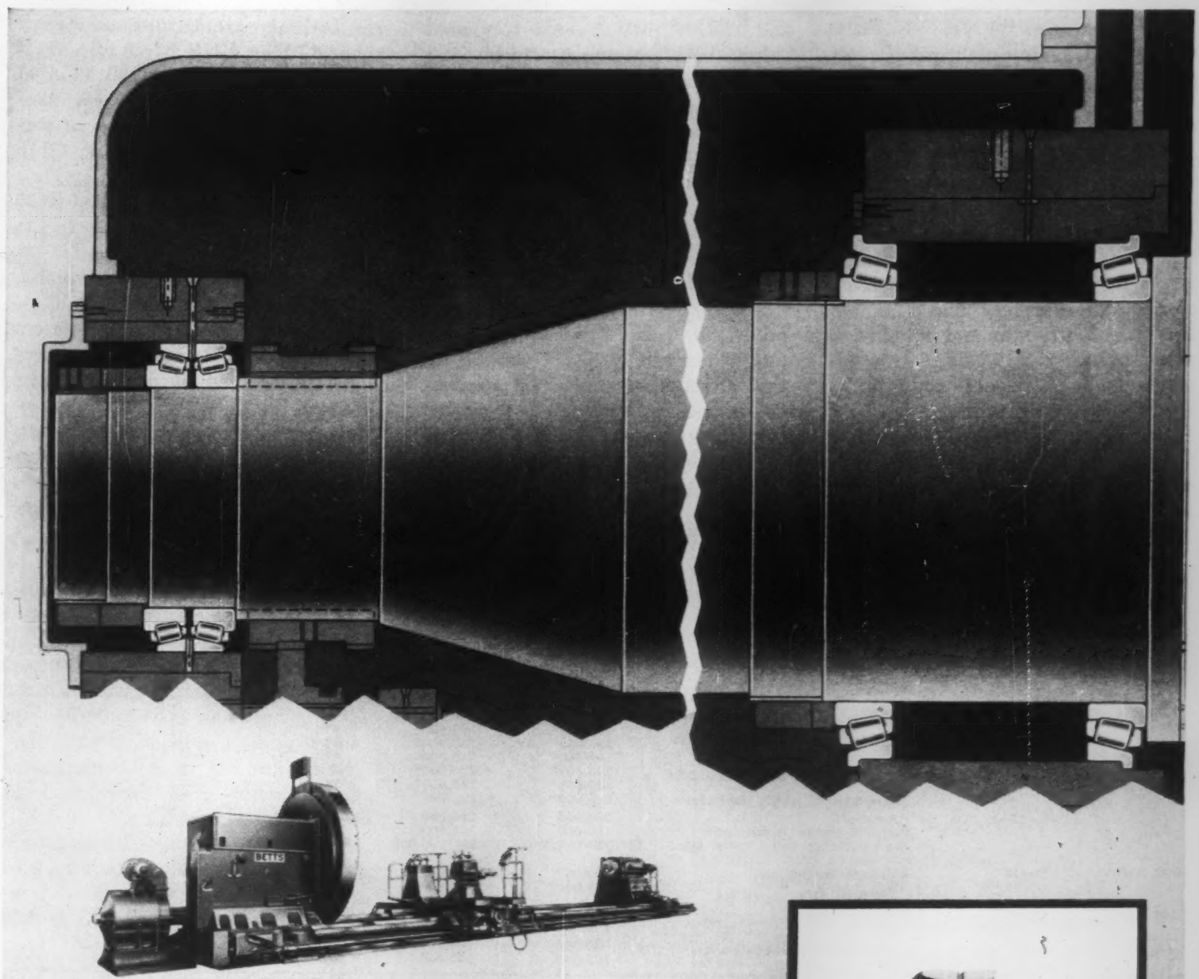
Components ranging from foil for honeycomb to very thick heat-treated parts seem possible with B120 VCA, since the alloy has extremely great and deep hardenability. Strip, foil, bars and billets have been made, and some mill products (sheet and wire) are available in limited quantities.

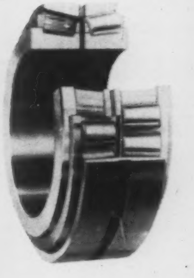
Primary applications foreseen for the three new alloys are as sheet, although structural shapes and forgings make sense. Aircraft skins, stiffeners and primary shapes of B120 VCA are currently under test; honeycomb assemblies appear ideal, since the alloy can be brazed; and casing skins, pressure tanks, and structural members for several-hour service at 1000 F (or shorter times at 1400 F) seem like excellent applications. Aircraft and missile bolts and rivets are also potential uses.

Corrosion resistance is excellent—comparable to other titanium alloys. So chemical-industry or marine applications may be a future use. But aircraft and missile applications, in which high strength, light weight and weldability are critical, are almost a certainty.

Cost will be comparable to other titanium alloys. Although base costs of the alloys, pound for pound, are some 15 times that of stainless steel, formed components are expected to cost only 2 to 3 times those made in stainless steel. Reasons: Lighter weight of titanium; forming cost in both cases is a high percentage of total cost. So the alloys will have particular advantages where their light weight (or high strength-weight ratio) and corrosion resistance can be used to advantage.

B120 VCA is the first heat-treatable "all-beta" alloy. The beta structure—which gives easy form-





These ultra-precision Tapered Roller Bearings were specially designed and built by Torrington for Consolidated Machine Tool Company's 144" lathe front and rear-head-block positions.

Torrington ultra-precision in large sizes!

The two-row Tapered Roller Bearing shown above is 21.5000" OD, has a maximum radial and face runout of .0003", with rotating inner ring and stationary outer ring. At 100 rpm, its radial capacity is 304,000 pounds, its thrust capacity 215,000 pounds.

The single-row Tapered Roller Bearing is 36.000" OD, with a maximum radial and face runout of .0003". At 100 rpm, its radial capacity is 319,000 pounds, thrust capacity 272,000 pounds.

Precision in large bearings reflects Torrington's specialized skills and equipment, which enter into the production of every Torrington Bearing, large or small, special or standard. You may not require such precision, but you can be sure your bearing order will receive the care that makes Torrington quality a by-word of industry. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

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ability and high ductility—can be produced by air cooling or solution quenching to a soft, formable condition. In this condition, formability of B120 VCA is as good as, or better than that of commercially pure titanium.

When aged from 50 to 100 hr at 850 to 900 F, some of the beta transforms to "alpha" plus intermetallic compounds. This results in a marked increase in strength and toughness, plus ability to be welded. Double-step aging sequences promise to lower total aging time to 10-20 hr. Reannealing for severe working is simple, since heating to the transition temperature and air cooling are all that is necessary.

The two other alloys, C105 VA and C115 AMoV, have a combined "alpha-beta" structure which must be quenched to retain the beta phase. Aging characteristics of all three alloys are not markedly affected by forming, and have nondirectional sheet and strip properties.

On short-time tensile tests of the usual 1 to 2 minutes, the new B120 VCA alloy has a comfortable strength-weight advantage over other materials to 1000 F. For longer test periods, such as 500 hr, this advantage is retained to 600-800 F. Beyond this limit, the other two new alloys, C105 VA and C115 AMoV, plus earlier alloys (C135 AMo, C120 AV, RC 900), do better.

Both B120 VCA and C105 VA can be brake-formed to smaller radii than A70 or C110 M titanium alloys. Hot forming of B120 VCA at 200-400 F gives more uniform elongation, but hot forming is not recommended for C105 VA or C115 AMoV.

Solution-treated or annealed B120 VCA or C105 VA can be fusion welded by techniques similar to other titanium alloys (essentially, shielding from air). In B120 VCA, the weld tends to age at a different rate from the base metal, so present work is directed at achieving best strength-ductility combinations simultaneously in weld and base metal. In C105 VA, solution treating after welding and before aging gives the best strength and ductility combination.

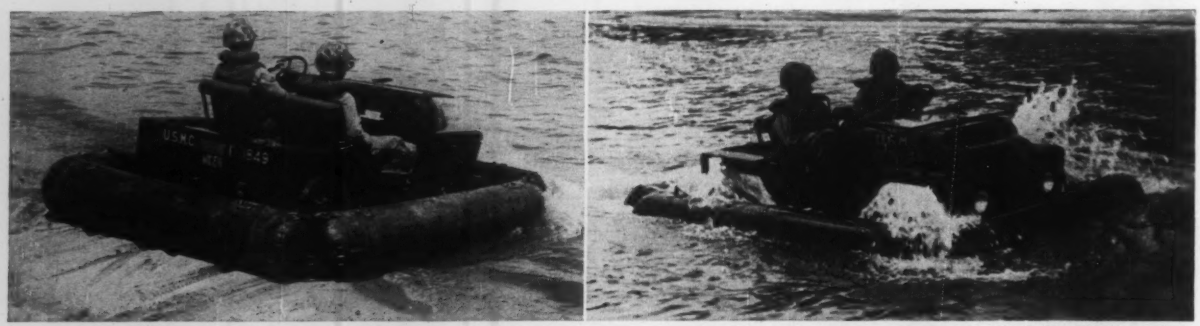
Heat-treated tensile strength: 240,000 psi!

Titanium Alloy	Form	Condition	Yield Strength 0.2% Offset (psi)	Ultimate Strength (psi)	Elongation in 2 in. (per cent)	Reduction of Area (per cent)	Composition
B120 VCA	Sheet	Solution treated/annealed	135,000	140,000	15	40	13 V, 11 Cr, 3 Al
		Aged	170,000*	190,000*	6*		
			180,000*	200,000*	5*		
			190,000*	210,000*	4*		
			200,000*	220,000*	3*		
			220,000*	240,000*	2*		
		Experimental aging technique	245,000	257,000	3		
	0.002-in. Foil	As-rolled	230,000	240,000	3.3		
		Solution-treated/annealed	136,000	145,000	10		
		Slow-cooled brazing cycle, aged	167,000-168,000	192,000-195,000	4-6	21-26	
C115 AMoV	Sheet	Solution-treated	90,000	140,000	16	..	4 Al, 3 Mo, 1 V
		Aged	168,000	190,000	8		
C105 VA	Sheet	Solution-treated	55,000	110,000	18	36	16 V, 2½ Al
		Aged	165,000	180,000	5.5	17	
	Bar	Solution-treated	30,000	105,000	16†	30	
		Aged	182,000	190,000	5†	17	

B120 VCA cold-headed bolts, 0.505-in. diam, with fillet and cold-rolled threads: Solution treated/annealed—150,000 psi ultimate shear, 95,000 psi double shear. Heat-treated, 123,000 psi double shear.

B120 VCA brazed honeycomb, beam-shear test on 2 x 6 x ⅝-in. samples: With B120 VCA face material and core, 1245 psi load to buckle. With heat-treated 17-7 PH stainless face, B120 VCA core, 600 psi (1200 psi max).

*Minimum. †In 4 diameters.



U. S. Marine Corps photo

TIRES DOUBLE AS WATER WHEELS to make this new Marine Corps personnel carrier both land and seaworthy. Four inflatable pneumatic floats, carried as standard equipment, suspend the vehicle at wheel depth, while oversize serrations on the tire treads provide water traction for propulsion and rudder action. Called Mighty Mite, the four-place amphibian is also helicopter transportable—it weighs only 1700 lb—and is powered by a V-4, air-cooled engine. Mid-American Research Corp., Wheatland, Pa., developed the new vehicle. American Motors Corp. will build 250 units for troop tests by the Marine Corps.

Machine Tough Metals with Electrochemical-Tool Techniques

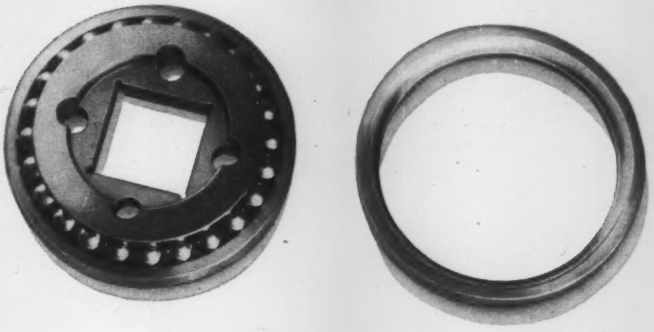
SCHENECTADY, N. Y. — Any metal which is difficult to machine mechanically—carbides, high-temperature aircraft alloys, and extremely brittle materials—can be machined by a new technique. The unusual method, now under study at the General Electric Co.'s General Engineering Laboratory in Schenectady, N. Y., uses chemicals and electricity instead of ordinary metallic cutting tools.

Laboratory engineer A. E. Howe explains the electrochemical machining technique as a close relative of the plating mechanism. Electrochemical dissolution is accomplished by a cathode-anode circuit. He says, "In electromachining, the current is channeled to a particular area where it causes electrochemical dissolution. The workpiece acts as an anode. It is dissolved as an anode is dissolved in an electrolyte, with metal atoms going into solution as ions."

Mr. Howe reports cutting rates better than 0.001 in. per sec. Work has been done to a tolerance of 0.0001 in. With the new system, he says, there is no mechanical disturbance and no cold working of the metal surface. Production equipment is now being developed.

Electrochemical dissolution machines metals. Illustrative photo shows gravity feed only; in actual application, precision feed must be used. There is no physical contact of the electrolytic cutting tool and the workpiece. Minute space between tool and workpiece forms continuous path for electrolyte from cathode to the workpiece anode.

Square-Hole Ball Bearing Simplifies Antenna Design



This radar bearing, 1.500" OD, carries 3000 lb. thrust while turning through 180° at 90 oscillations per minute. The split outer race permits larger ball complement and increased load capacity.

In planning the mechanical design of a radar antenna, the designer found that by using a ball bearing with a square hole, he could avoid limitations imposed by standard bearings. To bring this dream to reality, he had Industrial Tectonics design and produce the special bearing shown above. This has resulted in (1) a simpler and less costly design of the assembly that the bearing carries, and (2) a stronger and more rigid support.

In this and many other ways, the availability of ITI special bearings permits new freedom of design, and new economy. Remember —

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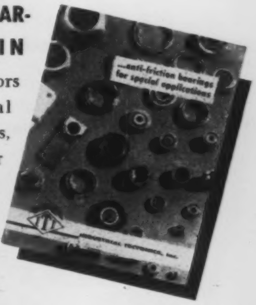
NEW 24-PAGE BEARINGS BULLETIN tells about the factors involved in special bearing applications, and describes our work in this field. *Write for Bulletin AFB-2.*



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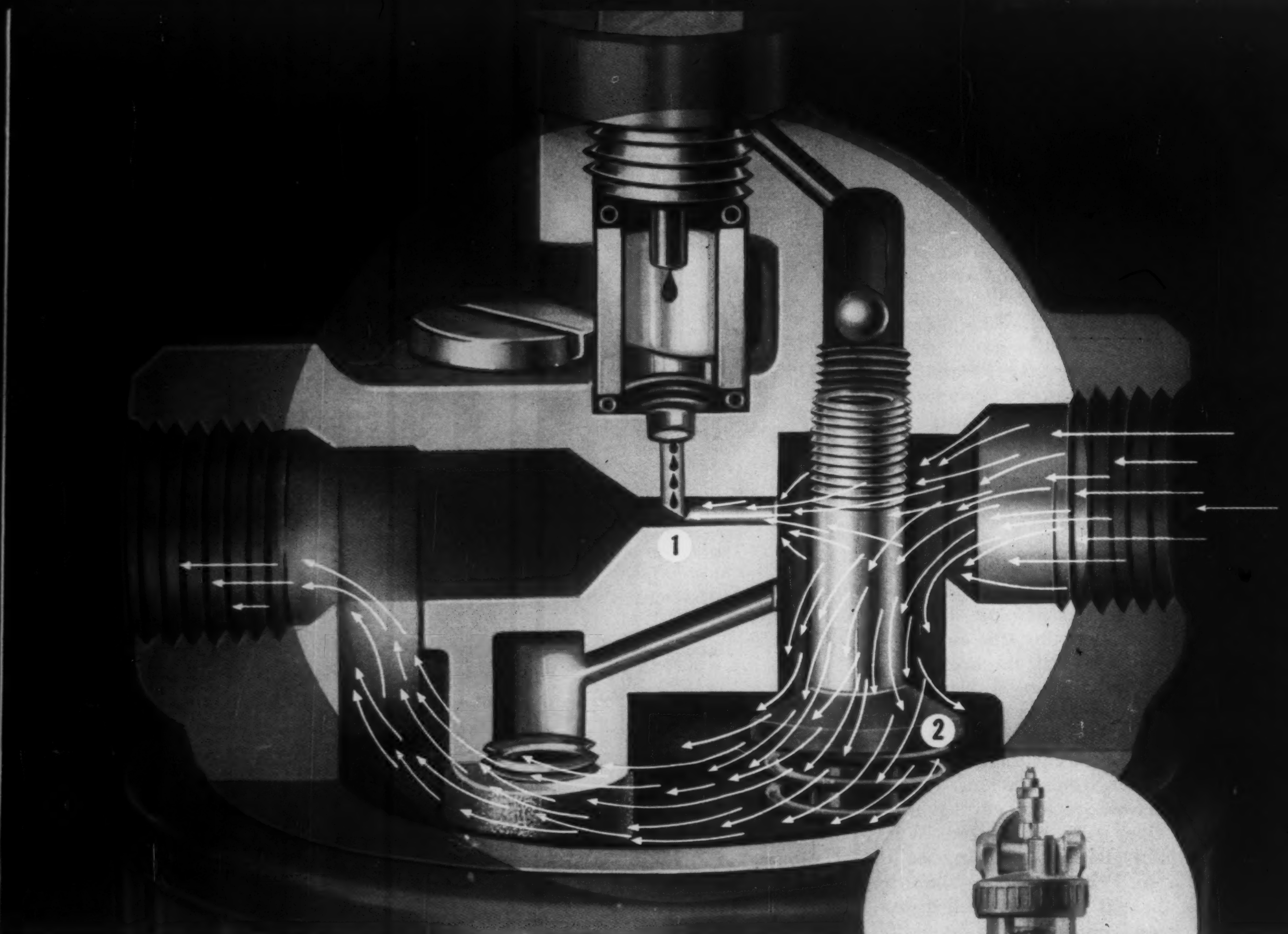

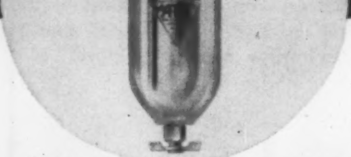

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420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
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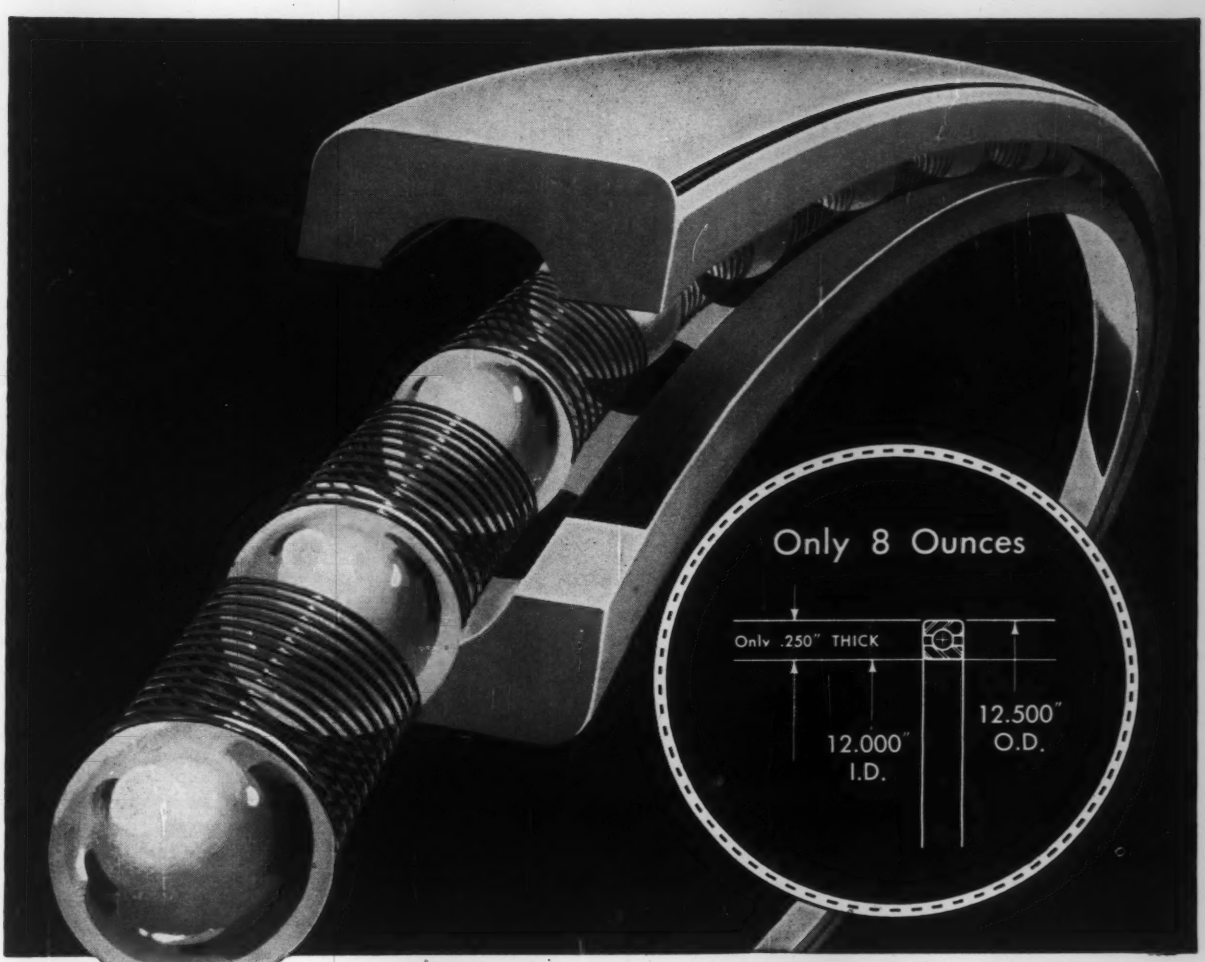

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HERE'S a typical example of Kaydon's *Reali-Slim* unique radial ball bearing that's finding wide application in practically every industry. *Reali-Slim* are the world's finest thin-section bearings and proportionately are thinner than a wedding ring. The bearing illustrated here is 12.000" I.D., 12.500" O.D., .250" thick — weighs less than 8 ounces. Designed for minimum weight and space limitations, it has a static load capacity of 5,520 lbs. and 894 lbs. at 100 rpm.

If you're looking for *Reali-Slim*, lightweight, radial ball or roller bearings, look at Kaydon's *Reali-Slim* line. Besides hundreds of standard *Reali-Slim* designs, there's a wide variety of special races, seals and separators to meet special bearing problems. What's more Kaydon is able to produce these *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual. In addition, Kaydon bearing engineers are prepared to give you valuable help with technical bearing application problems.

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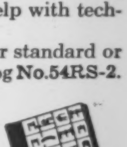

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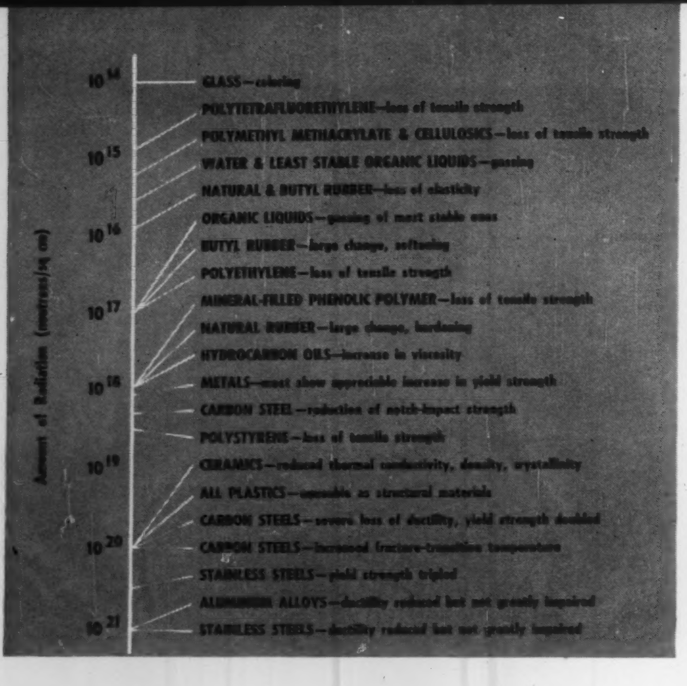
Circle 413 on Page 19

Material Mutations . . .

By **FRANK A. TWITCHELL** and
J. W. BLIZARD Jr.
Production Design Engineers
Northrop Aircraft Inc.
Hawthorne, Calif.



The effects of radiation on materials differ widely. Levels (high-energy neutrons) indicated are approximate and subject to variation.

A NEW PARAMETER has been added to the properties of materials—the effects of nuclear radiation.

Emitted by nuclear reactors or radioactive sources, atomic radiation makes significant and sometimes all-important changes in the properties of materials. The study, now in its infancy, covers only a limited number of changes. Some of these are beneficial; many are not.

Radiation processing opens two new fields to the designer. It permits him to make use of the unique properties of irradiated materials. It determines, to a great extent, the design of nuclear-powered equipment and other apparatus, to be located in a nuclear-radiation environment.

Metals

Structural metals resist deleterious effects of nuclear radiation better than most other aircraft materials; however, relatively high energy levels of radiation certainly change their physical properties. Exposure to radiation can create minute quantities of impurities and vacancies, affect the behavior of interstitials, and induce the controversial phenomenon of thermal spikes. The net effect of radiation on most normal structural metals is to increase the ultimate tensile strength and yield strength, but to reduce the ductility of the material.

The temperature of most metals under nuclear bombardment considerably affects the extent of "radiation damage" or property changes. In general, metals at high temperatures are less susceptible to effects from radiation. In fact, radiation damage is sometimes removed or reduced by annealing.

Most information concerning the behavior of structural metals in the presence of a high-energy neutron flux deals with metals used in atomic reactors. Of these, aluminum seems most resistant to nuclear damage. The changes found in irradiated steels are larger—as might be expected from their higher annealing temperatures. Austenitic stainless steel shows a slight tendency to transform to ferrite, but the changes are probably too small to affect its stainless quality. Carbon steels of the type used for pressure-vessel construction harden with considerable loss of ductility.

One benefit of nuclear radiation lies in using it as a substitute for cold working, to increase hardness and strength, or as a means of producing age hardening in certain metals. Thus, radiation offers a method of low-temperature hardening that may be used upon special shapes or in special applications, where conventional heating or mechanical working is not feasible.

Nonmetals

Nonmetallic compounds exhibit varied behavior in radiation fluxes. For example, materials like aluminum oxide, magnesium oxide, and sodium chloride show moderate electrical, thermal, optical, and density changes. Compounds such as quartz, on the other hand, reveal large density and structural variations after moderate irradiation; however, they maintain microscopic integrity.

Ceramics

Ceramics as a class resist radiation damage better than organic materials but are generally less resistant than metals. Ceramics normally are not utilized where material strength is required and little strength loss has been observed when they have been subjected to radiation. Nuclear radiation causes swelling and a loss in density of most ceramics. However, the density has been known to increase with some glasses. As with metals, radiation damage of ceramics can be removed or reduced by annealing.

High-energy neutron bombardment will color crystalline materials and decrease their thermal conductivity. In some glasses, radiation-induced coloration can be readily cleared by heating. Radiation

Modern Alchemist Uses Nuclear Radiation

Radiation Effects on Properties of Various Alloys

	Rockwell Hardness		Yield Strength (psi)		Tensile Strength (psi)		Ratio of Yield Strength to Tensile Strength	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1100-H14 Aluminum	8F	40F	18,000	23,000	20,000	27,000	0.9	0.85
1100 Aluminum	....	....	7,000	17,000	17,300	26,000	0.51	0.65
High-Purity Iron	....	....	18,000	31,000	36,000	37,000	0.5	0.84
Normalized Carbon Steel	....	....	50,000	93,000	75,000	97,000	0.67	0.96
Hardened and Tempered Alloy Steel	....	....	153,000	196,000	164,000	198,000	0.93	0.99
Austenitic Stainless Steel	81B	99B	37,000	97,000	98,000	115,000	0.38	0.84

Ductiles Before and After Irradiation

Material	Elongation at Breakage (per cent)	
	Before	After
1100 Aluminum	38	21
1100-H14 Aluminum	22	20
Normalized Carbon Steel	22	5
Austenitic Stainless Steel	49	25
QMV Beryllium	1.4	0.2
356 Aluminum	2.7	0.6
Molybdenum	44	0

damage to ceramics seems minimized at higher temperatures.

Plastics and elastomers

Of all the materials studied, substances with molecular structures of plastics or elastomers are generally the most susceptible to nuclear radiation. One of two basic reactions, crosslinking or cleavage, is normally observed.

Crosslinking occurs when the molecular structure of the polymer is affected in such a way as to increase Young's modulus, impede viscous flux, and increase retardation of strain. These usually cause increased tensile strength, hardness, and softening temperature; decreased elongation, solubility, and elasticity; gas formation; and embrittlement.

Cleavage occurs when the molecular structure is affected in such a way as to decrease Young's modulus and reduce yield stress for viscous flow. This reaction usually causes decreased tensile strength, hardness, and elasticity; increased elongation and solubility; and sometimes, embrittlement or gas formation.

Irradiation of plastics and elastomers may also induce large dimensional changes, modify material density, affect electrical properties, distort color and transparency, and cause chemical decomposition.

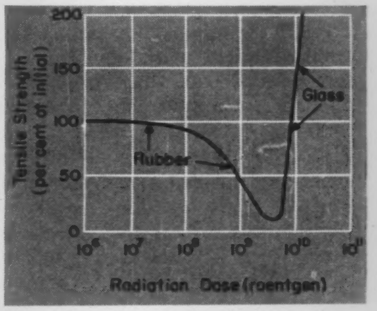
Elastomers that harden when irradiated behave in a singular manner. As the radiation dosage increases, their tensile strength decreases—almost to zero and then increases quite rapidly. At the point of sudden change, the elastomer's properties change to those of a glass.

Controlled irradiation can benefit some plastics and elastomers. For example, lightly irradiated polyethylene, when heated above its melting point will be rubberlike and can be molded into any desired shape instead of flowing. Thus, irradiation can simplify shaping of this material.

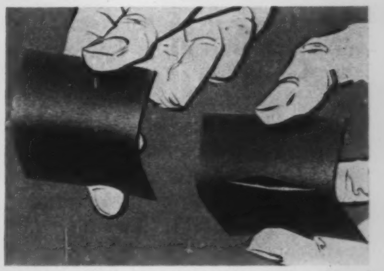
By employing controlled irradiation, rubber can be vulcanized without conventional vulcanizing agents. This technique can readily effect different degrees of vulcanization in different parts of the same specimen. But it must be remembered that irradiation of plastic and elastomers is currently a rather costly process and is recommended only when material property requirements cannot be attained by conventional means.

Grafted plastic by irradiation

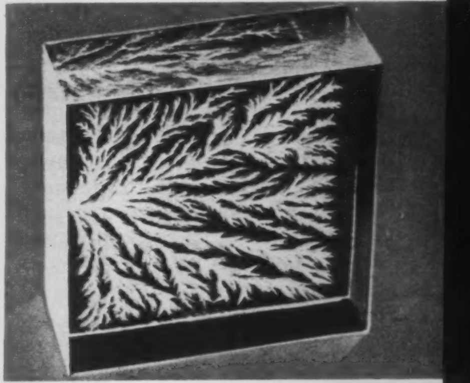
Radiation will interact with polymers (rubbers, plastics, and fibers) to form ions and free radicals. If a



Transition of natural rubber to glass



Stress-cracking resistance of irradiated polyethylene (left) is greater.



In irradiated Lucite block, high-speed electron particles accumulate in molecular structure. Slight tap on block after irradiation results in crazing effect as electrons create escape paths.

Types of Copolymer

Copolymer	Structure
Random	ABBABAAABABAB
Block	AAAABBBBAAAAB
Graft	BBBB─┐ AAAAAAA └─BBBBB

monomer is placed next to a polymer and the combination is irradiated, a propagation reaction will take place in which monomer units add to the radicals formed on the polymer. Each addition of a monomer to a free radical will result in the formation of a chemical bond with simultaneous release of heat. These combinations are called graft polymers.

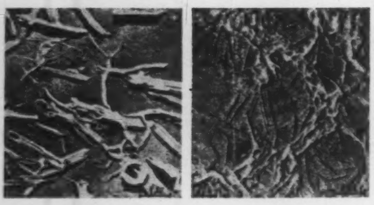
Final properties of a copolymer depend upon the manner in which the components combine. A copolymer of 60 *A* and 40 *B* may have different physical properties if the combination is a random copolymer, a block copolymer, or a graft copolymer. However, the fact that monomer *B* can be grafted to the polymer of *A* by irradiation does not necessarily mean that monomer *A* can be grafted to the polymer of *B* with the same efficiency. For example, styrene may be grafted to polymethyl methacrylate by gamma irradiation, but the reverse process is both wasteful and inefficient.

Certain graft copolymers have been made thermally; for example, graft copolymers of polystyrene and methyl methacrylate, which are difficult to make by irradiation, have been made by thermal polymerization. Other graft copolymers can only be made through irradiation; for example, a vinyl acetate-Teflon graft copolymer. Thermal synthesis of these two materials is extremely difficult, because Teflon is chemically inert.

There are two types of graft copolymers, internal and surface. In the internal type, the monomer polymerizes principally within the polymer film specimen; an example would be styrene and polyethylene. In the surface type, the monomer is grafted only on the periphery and not in the matrix; an example would be Teflon and vinyl acetate.

Lubricants

Lubricants have been subjected to gamma radiation of various intensities to determine their ability to resist radiation damage. Oils darkened in color and acquired an acrid odor similar to that of highly oxidized oils. For some, a slight floc was noted, but no sludge was evident.



Fresh sodium soap grease (left) is compared with sample which has been irradiated at 7.7 × 10^8 roentgens (right).

With gamma radiation dosages to 10^8 roentgens, all oils tested exhibited an increase in their viscosity and corresponding improvement in their wear characteristics with the exception of oils with chlorine-containing additives which became very corrosive.

All greases tested softened after gamma radiation dosages to 10^8 roentgens. It has been observed that higher gamma dosages reverse the softening trend, and eventually the greases become solid. The rate of change of each grease varies with radiation, according to the particular combination of oil, gelling agent, and additive. Those greases which show pronounced physical property changes show also a rather drastic change in fiber structure of the gelling agent.

Irradiation greatly increases oxidation resistance of most greases; however, the bearing life generally decreases with radiation dosage.

In general, the final effect of irradiation of lubricants is similar to severe oxidation. Lubricants darken and acquire an acrid odor; oils exhibit an increase in viscosity; and greases show marked changes in their original consistency.

Hydraulic fluids

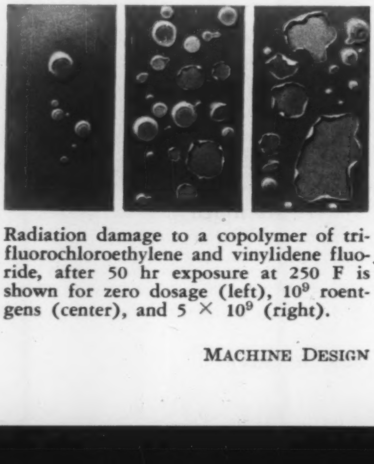
After irradiation, hydraulic fluids show viscosity changes similar to those found in lubrication oils. Generally, hydraulic fluids exhibit a decrease in viscosity under irradiation; however, certain hydraulic fluids such as chlorophenyl-silicone-based fluids solidify. Furthermore, many hydraulic fluids show a marked increase in corrosive properties on metals after nuclear irradiation. Another serious problem is that hydraulic fluid gases are evolved at rather high rates when exposed to nuclear radiation fluxes. To utilize hydraulic fluids, some means must be found to remove the generated gases in order to preserve the design operating characteristics of the hydraulic system. Not only do the gases that separate from the hydraulic fluid need to be vented off, but also those gases held in suspension or dissolved in the fluid must be removed.

Protective coatings

It would seem that the resistance of protective organic coatings to radiation damage could be predicted to some degree from data available on plastics and elastomers; however, complicated factors are introduced with pigments, plasticizers, and other coating ingredients.

In general, irradiated phenolic coatings retain their physical properties better than any of the other coatings evaluated. After having received a gamma dosage of 5 × 10^9 roentgens and later being exposed to a temperature of 500 F, these coatings maintained good abrasion resistance and adhesion qualities. The silicone-alkyd enamels appeared to be little affected by 10^9 roentgens radiation dosage. Radiation exposure of 5 × 10^9 roentgens, however, produced oxidation and crosslinking of the enamel and caused it to become powdery and brittle.

After exposure of 10^9 roentgens, both red and white 32 per cent phthalic anhydride alkyd enamels became discolored and embrittled. The white enamel exhibited a large increase in abrasion resistance and a large decrease in adhesion. The red enamel suffered a decrease in adhesion to a lesser extent. In contrast, black 32 per cent phthalic anhydride alkyd enamel softens with similar radiation exposure and shows decreased abrasion resistance.



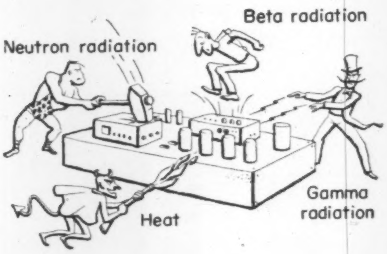
Radiation damage to a copolymer of trifluorochloroethylene and vinylidene fluoride, after 50 hr exposure at 250 F is shown for zero dosage (left), 10^9 roentgens (center), and 5 × 10^9 (right).

Epoxy coatings in general are severely degraded by radiation and show poor abrasion qualities and marked decrease in adhesion. Fluorinated vinyl coatings show improved properties with moderate irradiation, but as the dosage increases, they lose their good cohesion and corrosion resistance.

White nitrocellulose lacquers exhibit an extensive loss of all physical and mechanical properties after radiation exposure. Red lacquers are damaged to a lesser degree, becoming brittle and nonporous, and improving adhesion properties. On the other hand, with the exception of surface damage, black lacquers exhibit a significant increase in toughness and adhesion after radiation.

Electronic components

Electronic components have always been a major consideration in regard to their sensitivity to vibration, shock, and elevated temperatures. An environment including nuclear radiation increases the demands for the production of effective electronic components. Deleterious effects upon electronic components can be divided roughly into two classes. The long-term degenerative effects associated with total radiation dosages must be considered, and the undesirable effects of radiation flux density changes, or rate effects, on the entire electronic system must be realized. Unfortunately little or no testing has been accomplished with respect to rate effects.



Conductors

Conductors, usually metals, are relatively resistant to radiation environments. On the other hand, insulators are much more sensitive to radiation. The resistivity of insulators generally decreases inversely with the radiation field. A 99.9 per cent decrease in insulator efficiency has been noted in intense fields. Wires and cables are also affected in other ways by nuclear radiations. For example, potential "leakage" has been noted in the presence of a highly ionized field induced by radiation flux. Also undesirable local potential differences can be produced by "nuclear batteries" or charge displacements induced by nuclear collisions.

Semiconductors

Of all types of components, transistors are among the most sensitive to nuclear radiation. In fact, certain transistors have been reported to exhibit effects due to solar radiation. Nuclear radiation has much more pronounced effects, most of which are detrimental to transistor operation.

Irradiation of transistors creates undesirable electrical potentials and displaces atoms from their crystal lattice, among other reactions. These effects induce leakage currents, decrease gain, and eventually cause failure of the component. It appears that high-frequency transistors are best for use under neutron radiation; however, they show no particular advantage over their low-frequency counterparts under pure gamma radiation.

Semiconductor rectifiers are greatly affected by applied radiation. As radiation flux increases, the forward resistance is drastically increased and the backward resistance is reduced until the rectifier is useless. Under similar fluxes, experiments have been made with special silicon rectifiers that have remained in operation during the entire test. It is therefore considered possible that semiconductor rectifiers can be developed or modified to withstand more severe radiation environments.

Vacuum tubes

Because vacuum tubes vary greatly in size, complexity, and material composition, their resistance to radiation damage also differs considerably. Tests have shown that once radiation damage becomes apparent, the tubes deteriorate quite rapidly. The most common cause of failure seems to be deterioration of the seal or glass envelope and subsequent gas problems which promote cathode failure. According to recent tests, some of the tubes that failed earliest had boron in their glass.

Thus it appears that the principal problem is to keep gas out of the tubes by the use of more efficient envelopes. Titanium shows promise of overcoming some difficulties of irradiation. Its relatively high temperature strength and stability together with its ability to absorb gases make it ideal for vacuum tube uses. Recently developed titanium ceramic tubes have operated at temperatures up to 800 C and may show far greater resistance to nuclear radiation environments.

Resistors

In general, the higher the value of a resistor, the more subject it is to ill effects from radiation. Nuclear radiation induces changes in the conducting material of a resistor, in its insulating materials, or in both, resulting in a lowered resistance. Not only does the radiation dosage produce the over-all effect of decreased resistance, but also the resistance of the resistor can fluctuate when exposed to variable radiation fluxes or intensities. This latter phenomenon is referred to as "rate effect." From testing it is apparent that sensitivity of resistors to irradiation also varies markedly according to the manufacturer. Wire-wound power resistors are much less affected by radiation influences than other types.

Capacitors

Ceramic, mica, glass, electrolytic, oil, and plastic-dielectric type capacitors have been subjected to reactor irradiation. Except for some temperature effects, capacitance varied only slightly with reactor power, but was generally much more sensitive to exposure dosages. Electrolytic capacitors failed in about one-tenth of the standard exposure time. Irradiation of oil-impregnated capacitors caused gas evolution and subsequent swelling and leaking of the capacitor. Plastic dielectric capacitors followed no general pattern of radiation damage. With the exception of a few isolated cases, ceramic, mica, and glass capacitors were superior to other types and exhibited little or no radiation damage.

Metallic cellular-core structures have found wide acceptance. A new manufacturing process promises fast production and . . .

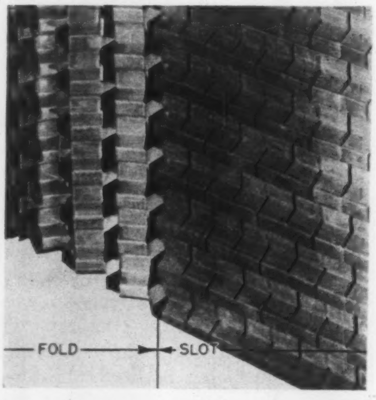
New Shapes in
Honeycomb

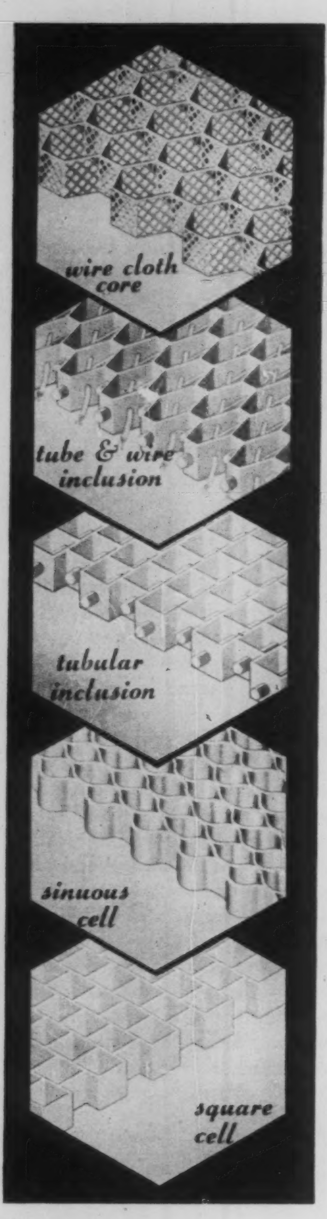
A CONTINUOUS METHOD of producing preformed cellular core structures, developed by Formacel Corp., permits variation of material thickness, cell size, and finished core dimensions. In addition to hexagonal —or true honeycomb—cells can be formed square, diamond, sinuous, or in many other variations designed to meet specific requirements.

Cell walls can contain holes of any size and shape in intercell alignment to accommodate tubes, wiring, harnesses, or other functional inclusions. Once fabricated, Formacel produces a cohesive structure by virtue of its mechanical configuration. Honeycomb is not dependent upon any bonding media to "hold itself together." The machine-finished product is to final dimensions, requiring no further stretching or compressing. This results in an intercell dimensional stability which is said to be difficult to achieve by other high-volume processes. All operations involved in the Formacel method are described as adaptations of standard, production techniques, combined in a single machine tool.

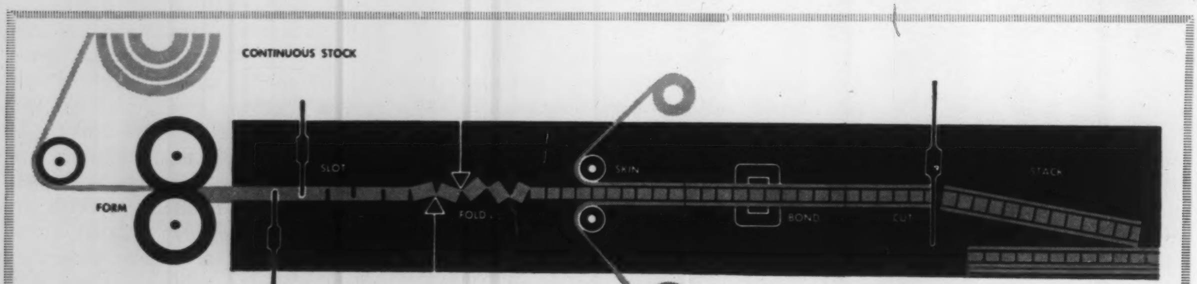
A typical installation would continuously produce a cored, load-bearing structural building panel, 48 in. wide by 96 in. high and 3 in. thick, at the rate of 4000 per month. The metal panel would weigh approximately 65 lb total or about 2 lb per sq ft. It would be cored with aluminum automatically formed to hexagonal, square, diamond, or corrugated cell configurations with panel facings or "skins" structurally integral with the core, to result in a highly favorable shear and compression strength to weight factor.

The process permits cored panels to be filled with foam plastic and to be finished on one or both sides with primer, lacquer, enamel, veneer, plaster board, or almost any other conventional inside or outside surface treatment.





▲ Variety of cell shapes are roll-formed, slotted, folded, and panelized in a continuous process. ▼



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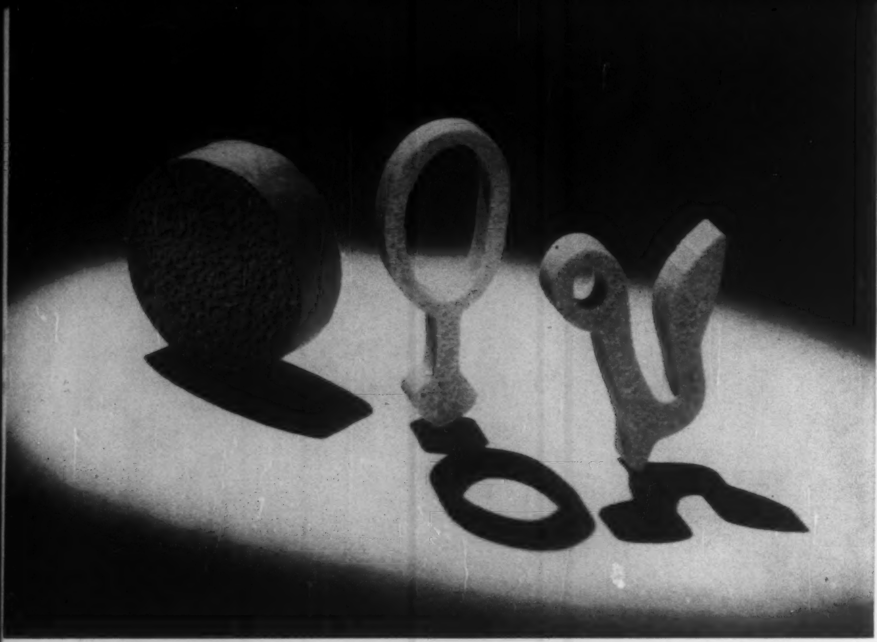


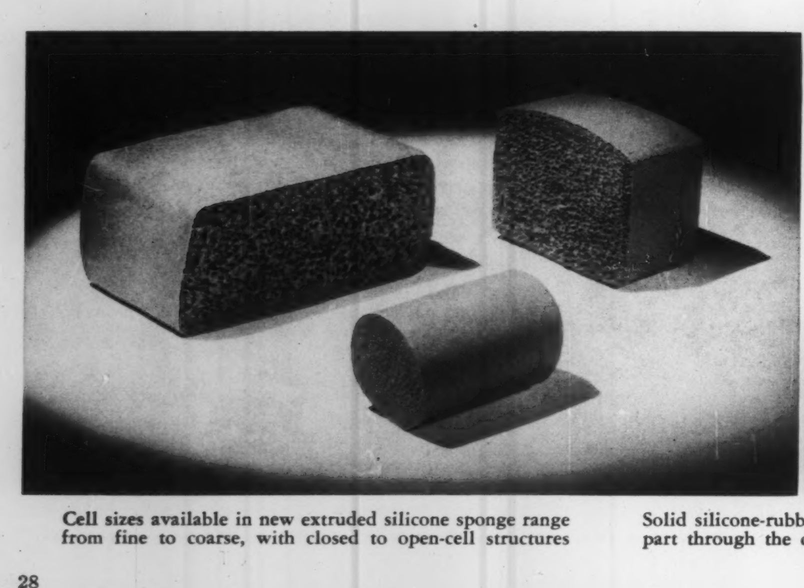
A new process for silicone-rubber sponge produces parts of almost unlimited length in complex cross sections

Extruded Sponge

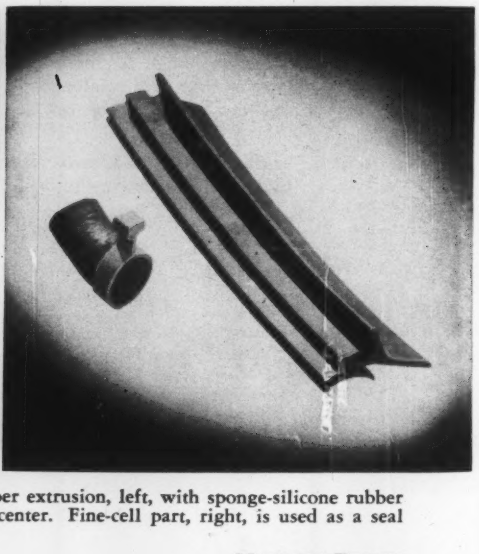
By RICHARD R. LONG
Director of Silicone Production
Stalwart Rubber Co.
Bedford, Ohio

SPONGE RUBBER is now being produced by extrusion. In a new process, silicone rubber is expelled from extrusion dies, then sponged to controlled cross sections. Continuous lengths can be made, since limitations of molding are avoided. The basic process can also be applied to calendering silicone-sponge sheets, plain or with heat-resistant fabric backing.

If it is physically possible to build the die, a complex configuration can be extruded and sponged in silicone rubber. Very special die designs are required; the die shapes bear little resemblance to the finished product. Only silicone rub-



Cell sizes available in new extruded silicone sponge range from fine to coarse, with closed to open-cell structures

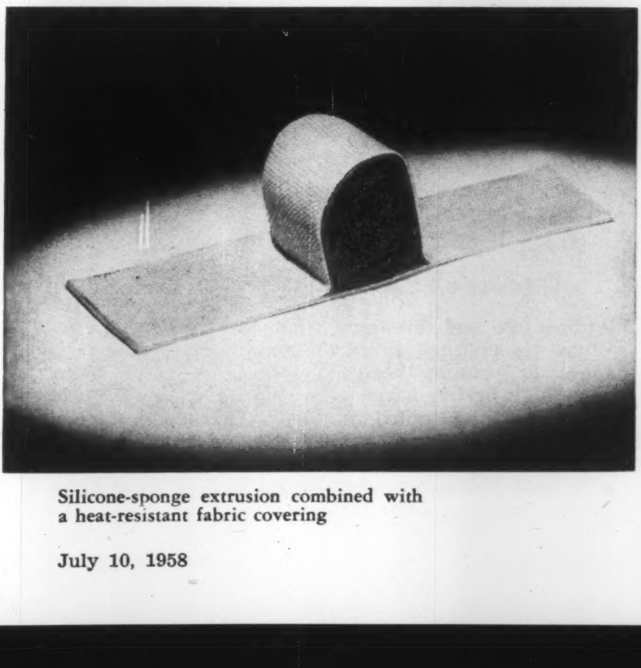


Solid silicone-rubber extrusion, left, with sponge-silicone rubber part through the center. Fine-cell part, right, is used as a seal

Rubber

ber has so far been produced.

Size of the extruded product before it is "blown" into sponge form is limited only by the size of the extruder head. At the present time, limiting dimensions for an extruded silicone part for sponging range from 1/16 in. min to 8 in. max before blowing. Size of the finished product after sponging is controlled by the use of special additives and precision curing. The sponge is usually blown from two to five times its extruded size. For example, a recent production run called for extruding a sheet of silicone sponge measuring $\frac{1}{4}$ in. thick by 8 in. wide. This sheet was then blown to $\frac{3}{4}$ by 24 in.



Silicone-sponge extrusion combined with a heat-resistant fabric covering

Silicone-sponge extrusions usually are produced in lengths up to 14 ft in complex cross sections and up to 300 ft in cord or other simple configurations.

Volume Lowers Cost: Costs of extrusion dies for silicone-sponge sections are only a fraction of those for conventional steel or aluminum molds. Special dies required for extruding silicone sponge usually run less than $100. The volume a die can produce is limited only by the speed of the stock as it comes from the extruder. Production costs are very low because of low equipment costs, coupled with high-volume production.

Properties Typical of Silicones: Generally, silicone sponge has all the important properties of ordinary silicone rubber. It also has the normal physical limitations of any organic sponge rubber. Eight silicone-sponge compounds have already been extruded or calendered into more than fifty different shapes. More are under development. The eight existing compounds can resist temperatures ranging from −160 to +500 F. Although silicones offer excellent resistance to fuels, oils, lubricants and other chemicals, the degree of resistance varies from one silicone compound to another.

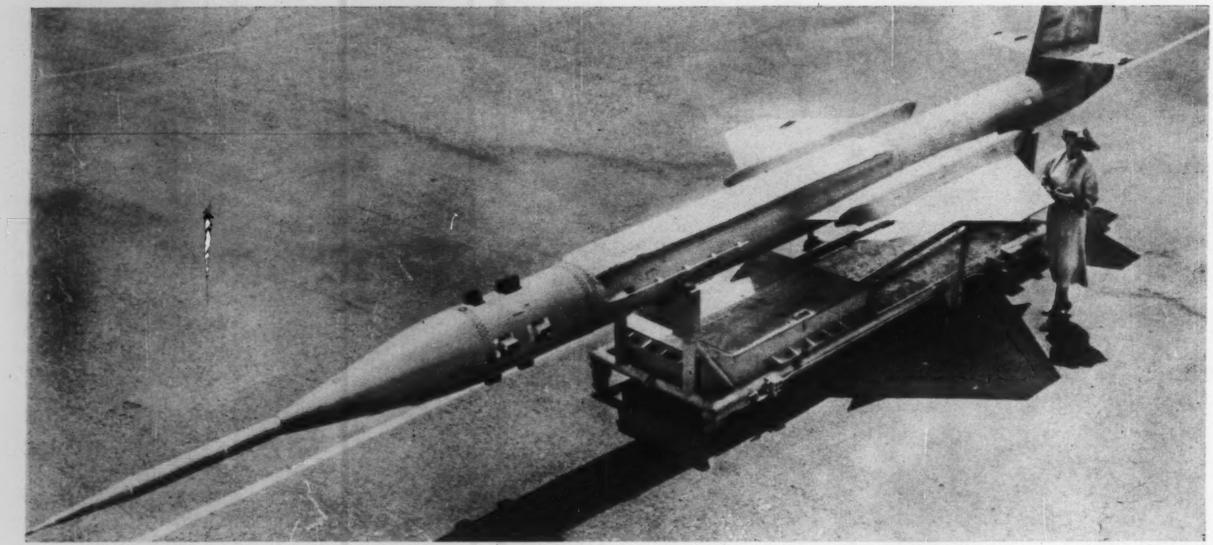
Silicone sponge offers high resistance to aging, sunlight and ozone, as well as excellent dielectric qualities at extremely high temperatures. On the other hand, like any sponge rubber, silicone sponge is low in tensile strength, elongation, and tear resistance. Its resistance to compression set is "fair" or "average."

New Applications Found: Silicone sponge parts are most widely used where heat stability and resiliency are important. Among new applications are gaskets for sealing aircraft windows, doors, bomb bays, and jet-aircraft heaters. Missile manufacturers are using noncombustible silicone-sponge sheets. Manufacturers of electric ironers for commercial laundries find that silicone sponge, used as backing, substantially reduces damage to buttons. Silicone sponge seals on tobacco curing ovens have helped reduce maintenance costs and oven downtime. An appliance manufacturer is now testing a combination silicone and silicone-sponge extrusion for use on electric appliances.

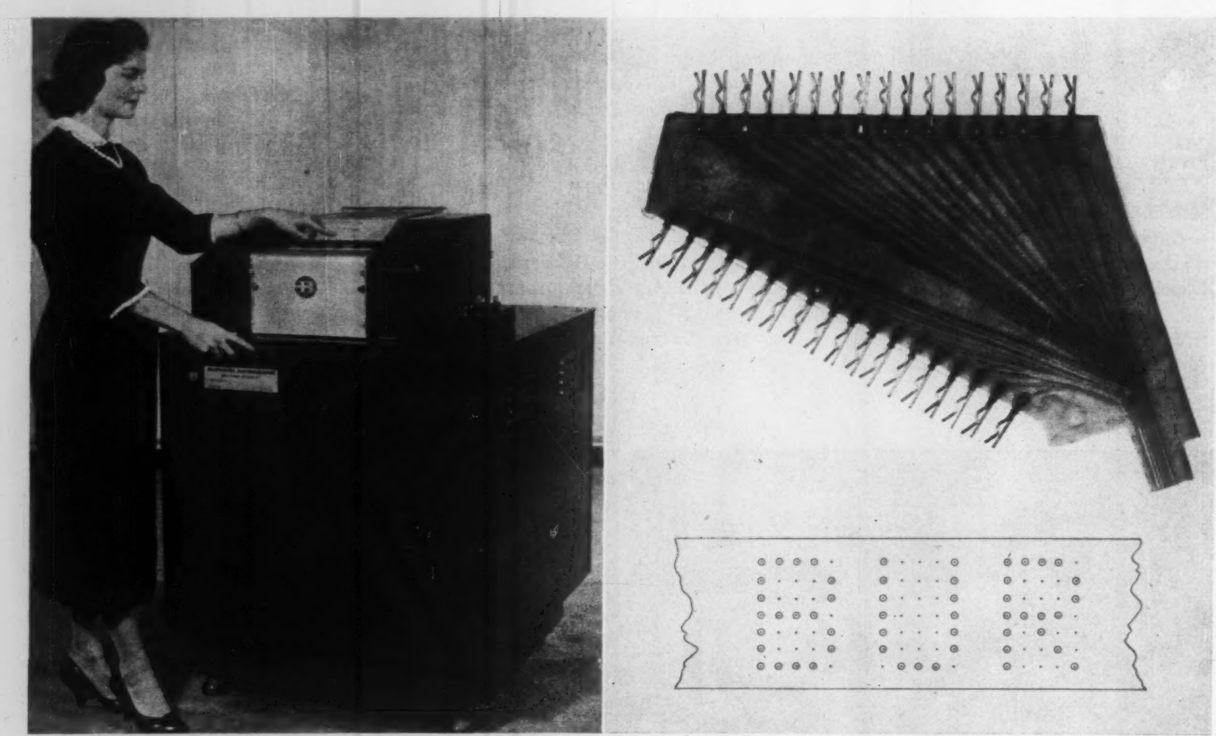
Tolerances: By careful control, silicone sponge can be blown to meet standards of the Rubber Manufacturers' Association for sponge. Tolerances of silicone-sponge cross sections also compare very favorably with those expected from the molded method.

Since it is difficult to arrive at a given durometer hardness for silicone sponge, sponge is manufactured to the density specified. Cell size can be controlled to meet virtually any specification. The normal rind characteristics of ordinary sponge can be expected on silicone sponge.

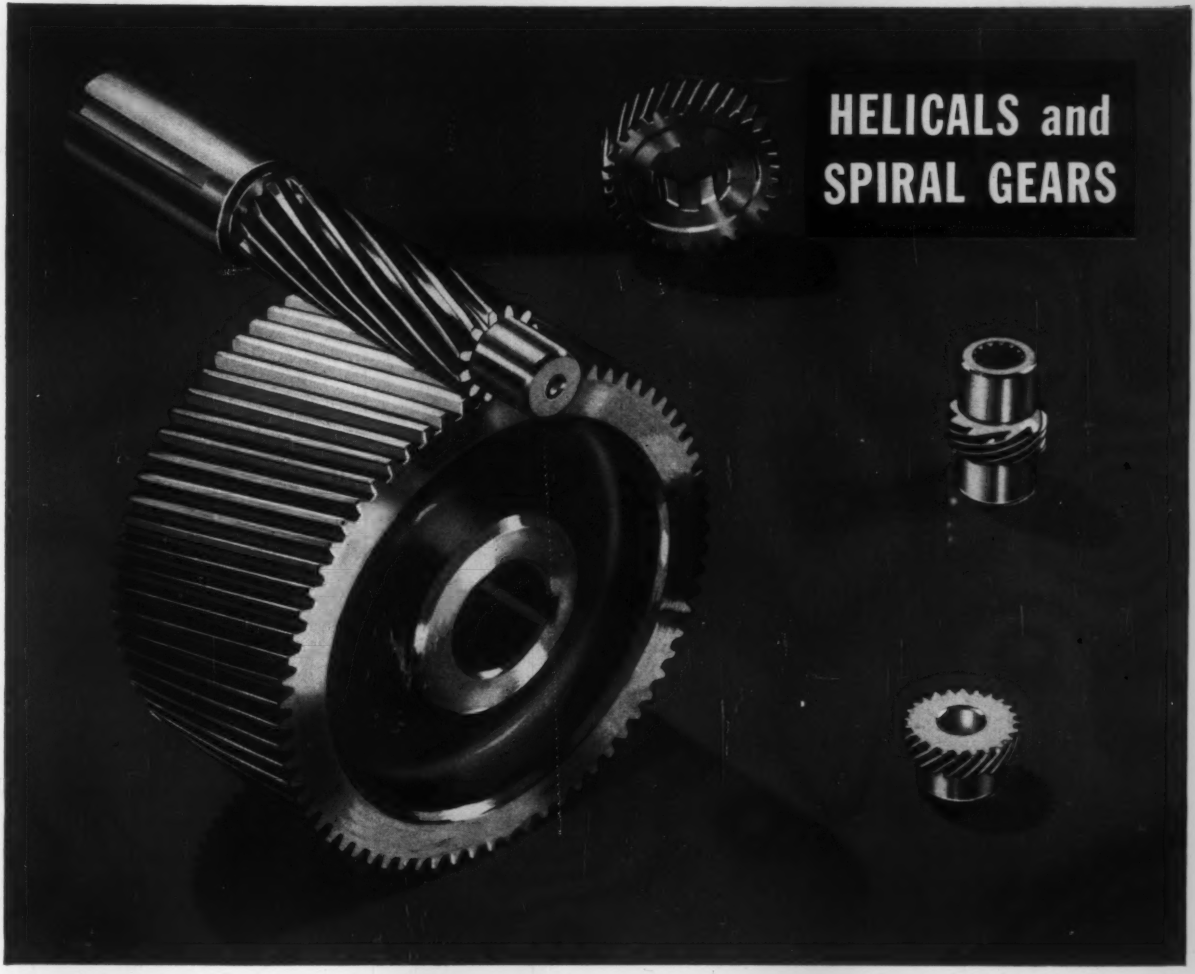
Calendering and Fabricating Possible: Sheets of silicone sponge to 36 in. wide can be produced by calendering. When blown, these sheets can measure up to 48 in. Calendered silicone-sponge sheets can be backed with Orlon, Dacron, nylon or glass fiber. Silicone extrusions can also be produced separately, then combined and cured at the same time.



RAMJET ENGINE TESTER, an advanced version of Lockheed's pioneering X-7 missile, will test fly a series of giant new ramjet powerplants designed for Air Force interceptor missiles. It can mount four different types of Marquardt Aircraft Co.'s latest air-breathing engines. The missile is air-dropped from a B-50 bomber and propelled to ramjet speeds by two underwing rocket boosters. Flight is controlled from a ground console, and repeat flights are assured by means of a unique parachute nose-spike landing technique.



ELECTROGRAPHIC RECORDING device receives messages and assembles the electronic impulses into printed characters and words at a speed of 1000 wpm. The technique, developed by the Burroughs Corp. of Detroit, electrostatically forms small charged areas on a high-resistivity surface such as a coated paper. The image is made visible by application of powdered ink, permanently fixed by the application of heat. The recording head (upper right) is made of 35 tiny wires leading into and through a triangular piece of plastic. Wires are polished flush with one corner of the triangle, or printing head, to form a rectangle seven wires high by five wires wide. A printing line is made by 72 heads assembled in a row. They do not touch the paper but are at a fixed distance from it. Electrical pulses charge any combination of the 35 wires in each head. The letters, shown magnified, are formed by specific wires as circled (lower right).



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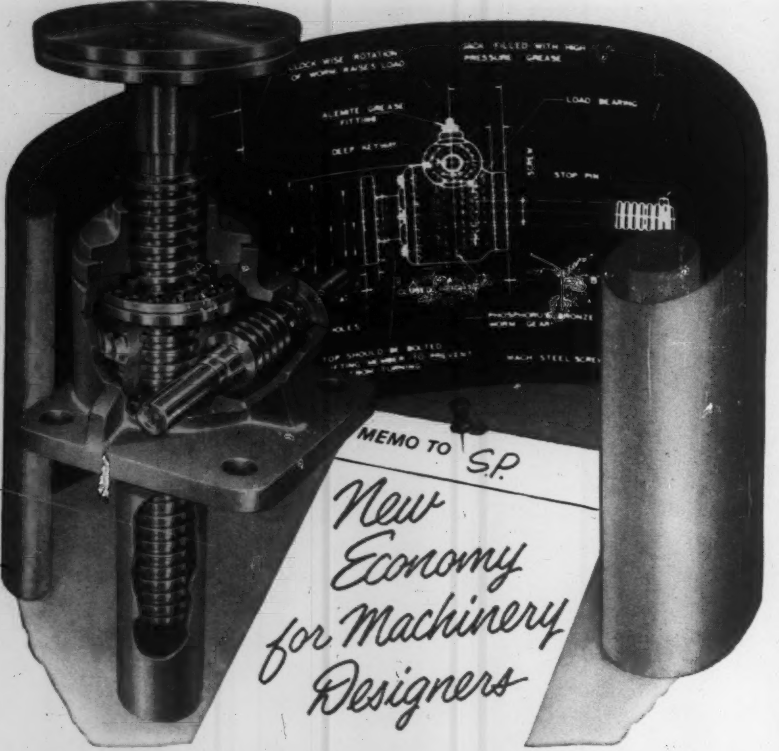
Circle 415 on Page 19


CLOCK WISE ROTATION OF WORM RAISES LOAD
JACK FILLED WITH HIGH PRESSURE GREASE
ALEMITE GREASE FITTING
LOAD BEARING
DEEP KEYWAY
SCREW
STOP PIN
PHOSPHOR BRONZE WORM GEAR
HOLES
TOP SHOULD BE BOLTED
MACH STEEL SCREW
MEMO TO S.P.
New Economy for Machinery Designers

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DUFF-NORTON WORM GEAR JACKS

The economies of standardized production now can be realized by machinery designers who use Duff-Norton worm gear jacks for accurate positioning of loads weighing as much as several hundred tons. After 25 years of experience and hundreds of custom designs, Duff-Norton engineers have produced a standard line of eight jacks ranging from 2 to 100 tons in capacity which will meet almost any requirements. When jacks are used in an arrangement, added economy can be realized in raising unevenly distributed loads, since all models now have a uniform raise which permits jacks of varying capacities to operate in unison.

Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bulletin AD-66-V, which includes drawings and full specifications.

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Ratchet Lever
Hand Chain, Electric

Circle 416 on Page 19

Metals Matters

Ferromagnetism without ferromagnetic elements is a recent achievement reported by Bell Telephone Lab. According to Bell, zirconium zinc becomes ferromagnetic below 35 K. Its ferromagnetic characteristics are similar to, and of the same order of magnitude, as those exhibited by conventional ferrites at room temperatures. Discovery of these properties gives scientists a completely new approach to the study of the fundamental characteristics of magnetism and magnetic materials. Until now, no ferromagnetic intermetallic compound was known that did not contain any ferromagnetic elements—iron, cobalt, nickel, chromium, manganese, or a few rare earth metals.

• • •

Ceramic-coated magnesium - thorium shows improved tensile strength with increased resistance to abrasion and corrosion, according to Bettinger Corp., Waltham, Mass. Ceramic coatings 0.001 and 0.002 in. thick, tested for missile applications, have survived 3000 F for short periods of time.

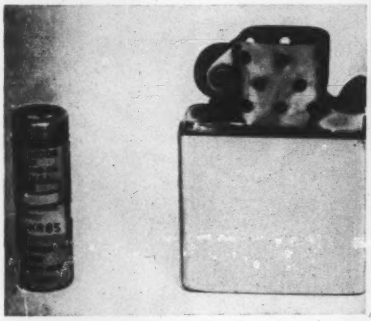
• • •

Pure beryllium forged bolts, with exceptional high-temperature properties and high strength-to-weight ratio, have been developed for use in hypersonic aircraft and missiles. New forging process, developed by Voi-Shan Mfg. Co., Culver City, Calif., permits forging of the high-tensile fasteners without disturbing molecular structure of beryllium.

• • •

Electroless nickel-plating of magnesium, developed by Dow Chemical Co., requires only immersion of the metal in a special nickel solution. Besides greater simplicity, Dow cites these advantages: Process involves catalytic reaction on metal's surface, so the coating fills imperfections, plating is uniform over both raised and low areas and does not build up on sharp corners, electroless nickel solders easily with acid-core solder, and, like electrodeposited coats, the new process builds coats to any desired thickness.

Optically set, turret punch press, which was described on page 34 of the June 12 issue, is manufactured by the Wiedemann Machine Co. of Philadelphia.



NEW NUCLEAR BATTERY, developed by Patterson Moos Div., Universal Winding Corp., Jamaica, N. Y., is claimed to be safer than present strontium-90 models, while delivering about five times the current. The new battery uses krypton-85 which diffuses quickly in air and is not absorbed by the body. Current rating is 10 to 1000 micromicroamp, with an open-circuit potential of several thousand volts. Operating and shelf life are an estimated 10 yr.

Number of Engineers in Unions Disclosed by NSPE Tabulation

ST. LOUIS, MO.—Approximately 40,000 professional engineers and scientists are represented by unions in the U. S., of which not more than 30,000 are dues-paying members, according to a tabulation released at NSPE's annual meeting. The 40,000 professional engineers represent something less than 10 per cent of the total U. S. engineering population.

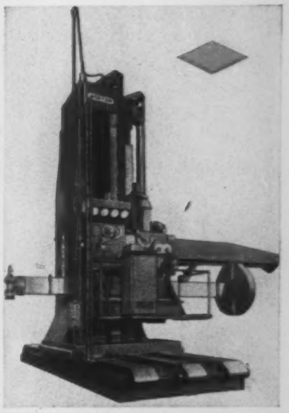
According to Wayne E. Ault, chairman of Engineers-In-Industry Subcommittee, this first tabulation is intended to help professional engineers and scientists evaluate the facts in the controversial "unionization" question. Pointing out that the Society is firmly opposed to unionization of professional engineers, Ault said that fact has not influenced the compilation of engineer-technician unions. "While actively seeking the advancement of the engineering profession within professional principles and outside of unionization, the Society has tried to recognize the fact that the first point in the solution of an engineering problem is to obtain all

(*Please turn to Page 36*)

DIAMOND NEWS ABOUT ROLLER CHAIN DRIVES, APPLICATIONS AND NEW PRODUCTS.

From great loads to small precision drives, machinery designers use stock Diamond Roller Chains and Sprockets to save time and money

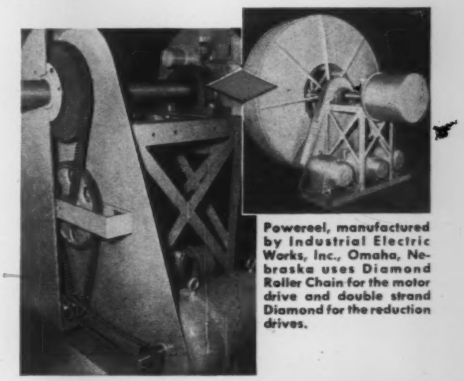
Huge 110 ton *Morton* 96-inch horizontal boring, milling, drilling and planing machine uses both three strand 2½" pitch and two strand 1¾" pitch Diamond Roller Chain between counterweights inside the vertical column and the saddle. Earlier machines used counterweight cables, but the satisfaction found in using stock Diamond Roller Chains has made them standard equipment with Morton for this type of service.



Morton has replaced counterweight cables on their big 96" Traveling Head Planer with three strand 2½" pitch and two strand 1¾" pitch Diamond Roller Chain due to their superior performance.

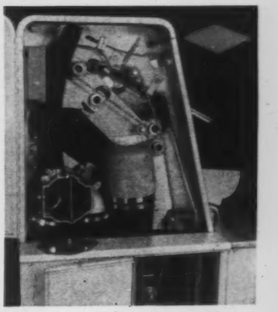
Powereel electric motor driven cable reels, can retract long lengths of cable with constant torque. They are used on gantry cranes, electric tractors, mine donkey cars, overhead cranes and all heavy mobile electrical equipment of this type.

Delivering the power from motors to take-up reel is a job handled by stock Diamond Roller Chain and Sprockets. Their uniform highest quality, long life and 98-99% efficiency deliver *all* the motor power for useful work. Center distances are not critical and thus allow for easy, logical placement of motors and shafts.



Powereel, manufactured by Industrial Electric Works, Inc., Omaha, Nebraska uses Diamond Roller Chain for the motor drive and double strand Diamond for the reduction drives.

P & H Arrow Whiteprinter handles over 97% of all cut sheet work with speed up to 75 feet per minute. Positive driving of many rollers from a single source is accomplished by using stock Diamond Roller Chain. Diamond quality is important here to assure smooth, quiet, dependable, maintenance-free operation.



End view of rollers showing motor and Diamond Roller Chain drive. Note how flexibility of Diamond Roller Chain and sprockets has allowed complete design freedom.

The new Diamond Stock Roller Chain and Sprocket Catalog 757 will help you select stock drives for your applications. Write now for your copy.

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DIAMOND ROLLER CHAINS

Circle 417 on Page 19

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Cutler-Hammer *ULTRAFLEX® DRIVES* provide outstanding savings in installation—operation—maintenance

No moving parts! Light, compact static power conversion units have replaced the conventional m-g set. Ultraflex Packaged Drives save up to 50% in valuable floor area . . . up to 75% in weight, permitting rapid, low cost installation or rearrangement of production machinery without special handling equipment or floor loading preparations.

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No moving parts! Simple static power conversion units require only a fraction of the time and effort needed to maintain conventional rotating type drives. With Ultraflex, there are no bearings, commutators, or brushes to service. No shafts to align. No couplings to maintain. No inertia loads to balance. No fans or filter to clean or change.

Ultraflex Packaged Drives come complete with operator's station, static power conversion unit, and heavy duty D-c drive motor. Standard Ultraflex Drives provide an 8:1 speed range with wider ranges available upon request. Optional features include dynamic braking, jogging, reversing, tach-generator speed regulation, etc.

Cutler-Hammer also provides a complete engineering service which will custom-design a static powered adjustable speed drive to meet your specific requirements. Get all the facts today, write on your company letterhead for new bulletins EN-64 and EN-65. CUTLER-HAMMER Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin.

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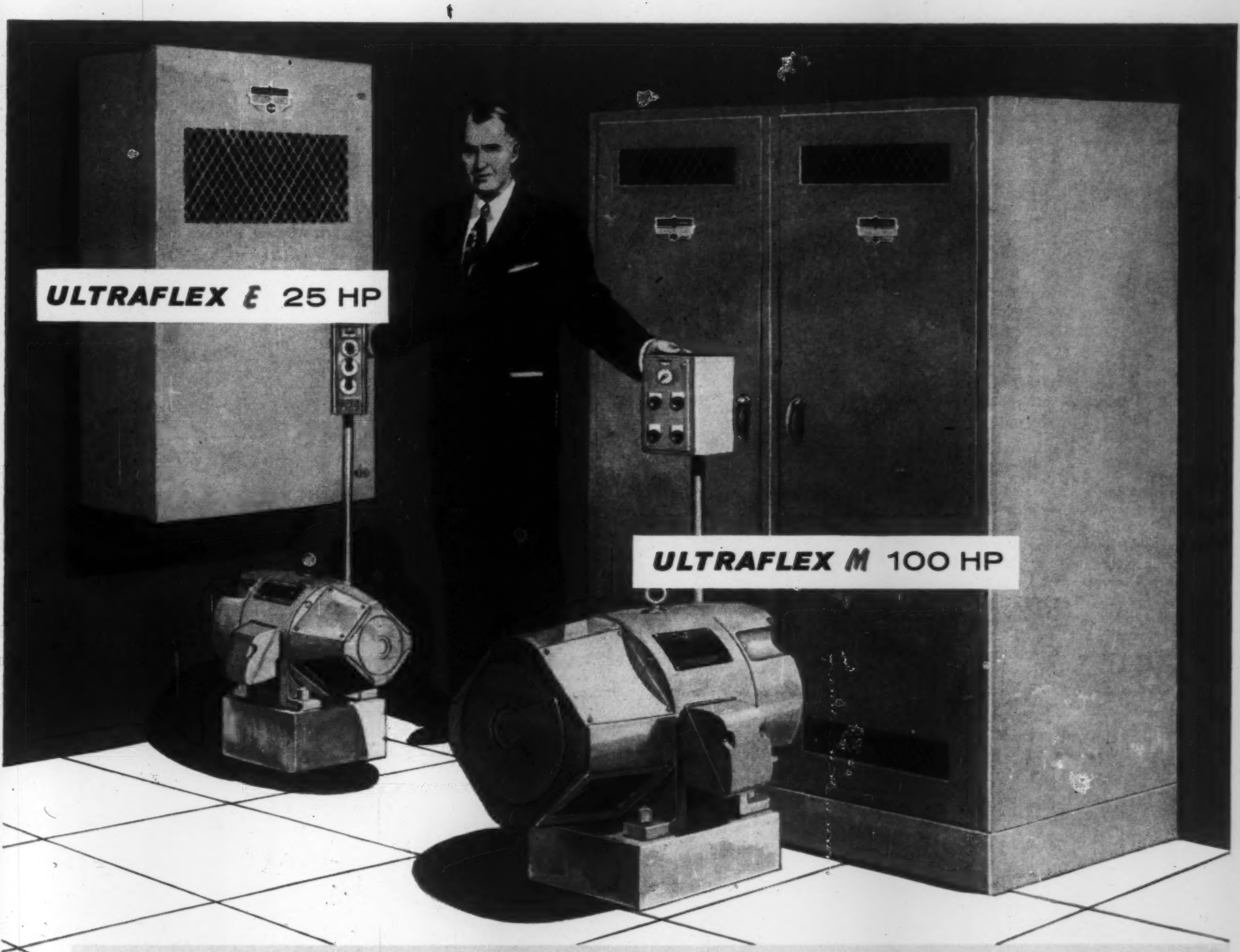


ULTRAFLEX DRIVES Pack More Power per Square Foot . . . More Power per Pound

HP	CONVENTIONAL m-g DRIVES SQ. FT.	CONVENTIONAL m-g DRIVES LBS.	ULTRAFLEX—E SQ. FT.	ULTRAFLEX—E LBS.
5	3.89	543	Wall Mounted	215
7½	3.89	550	Wall Mounted	215
10	5.44	647	Wall Mounted	215
15	7.0	983	Wall Mounted	330
20	9.5	1830	Wall Mounted	330
25	9.5	1990	Wall Mounted	330
30	9.5	2120	6.46	625
40	13.8	2350	6.46	625

HP	CONVENTIONAL m-g DRIVES SQ. FT.	CONVENTIONAL m-g DRIVES LBS.	ULTRAFLEX—M SQ. FT.	ULTRAFLEX—M LBS.
5	3.89	543	3.5	660
7½	3.89	550	3.5	870
10	5.44	647	3.5	870
15	7.0	983	3.5	1000
20	9.5	1830	3.5	1000
25	9.5	1990	4.5	1250
30	9.5	2120	4.5	1250
40	13.8	2350	4.5	1250
50	17.8	2980	11.7	2200
60	23.3	4070	11.7	2200
75	23.3	4800	11.7	2200
100	25.2	5700	11.7	2400

ULTRAFLEX E 1 HP to 40 HP

Electronic Type Adjustable Speed Drives

Ultraflex E is the simplest, most flexible, most dependable electronic adjustable speed drive on the market today. Heavy duty power tubes have replaced all "radio type" components assuring maximum efficiency and maintenance-free operation. Standard features of design include a closed loop voltage feed back system for accurate voltage regulation, current limit control, and static rectifier field excitation. Compact design permits wall mounting of the control units up to 25 HP.

ULTRAFLEX M 1 HP to 200 HP

Magnetic Amplifier Type Adjustable Speed Drives

Ultraflex M Packaged Drives set new standards for ultra-efficient, ultra-responsive operation. Fully 15% more efficient than conventional rotating type drives, the static magnetic amplifier power conversion unit avoids all power losses due to friction, windage and the necessity of transferring power across multiple air gaps as in rotating machinery. Standard Ultraflex M drives are equipped with a closed loop voltage feed back system with IR compensation for accurate voltage regulation, current limit control, and static field excitation.

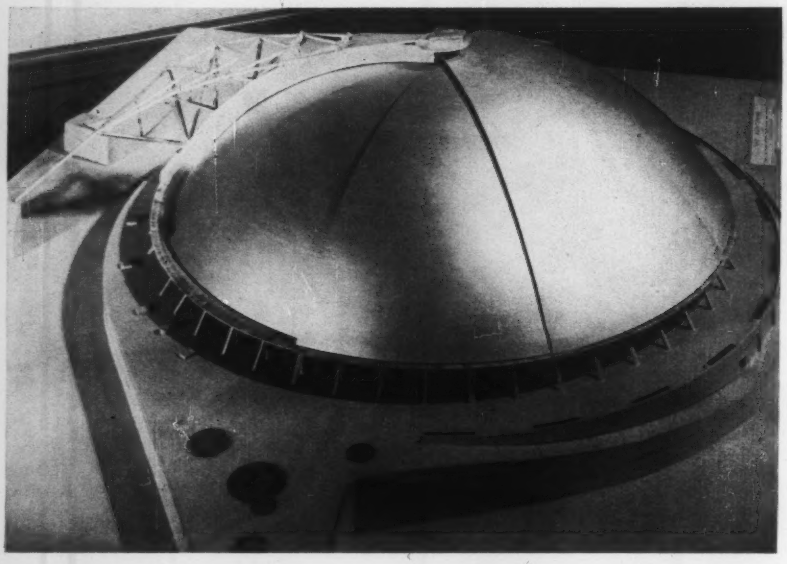
Circle 418 on Page 19

(Continued from Page 33)

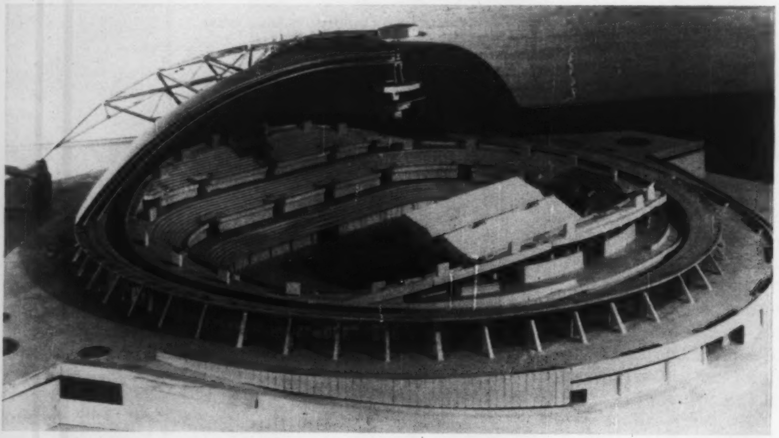
the pertinent facts."

Twenty-eight collective bargaining units are included in the first tabulation of unions representing engineers/scientists and/or technicians. The units are limited to those in which the professional or technician element is predominant, and does not include over-all unions which may have a sprinkling or small percentage of engineers or technicians. When professional and nonprofessional employees — technicians, draftsmen, etc.—are lumped together, the unions represent approximately 63,000 employees, of which approximately 37,000 are dues-paying members. The number of professional employees in these heterogeneous units are believed to be extremely small. The tabulation will be revised and updated periodically as additional information is received.

Ault pointed out that the claims regarding union representation or membership have varied widely, due mainly to lack of adequate definition and exaggerated union claims.



RETRACTABLE DOME of stainless steel will control the weather in Pittsburgh's new civic arena. Six movable sections roll over two fixed sections to open the big structure. In the closed position, mechanical seals keep the weather out. Design calls for 20 and 22-gage type 302 steel in a special, dull finish. The 415-ft diameter dome will cover 7500 to 14,000 persons, depending on event and seating arrangement.

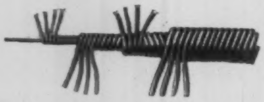


(Advertisement)

STRENGTH WOUND INTO IT

Research has proved that a light flexible wire with several alternate layers of wire wound around it produces a cable more flexible than a single wire of the same diameter and is capable of carrying a much higher torque. Flexible shafts are composed of this type cable plus a flexible casing which provides protection from dirt, grime, or grease.

There are two types of flexible cables used in flexible shaft assemblies. One is the power drive flexible cable in which the wires are wound in alternate direction. The outer layer of wire determines the direction rotation and is made to tighten when in use to add strength and form a practically unbreakable unit. The main advantage of the power drive flexible cable is its simplicity of alignment, as it is capable of transmitting power over, under, and around any obstacle between the drive and the driven elements.



Power drive cable with wires partly unwound to show construction of the cable.

Section of remote control cable showing superimposed layers of wire wound in opposite direction.

The other type of flexible cable is the remote control flexible cable which due to being constructed of smaller gauged wires than the power drive cable, and wound by a special process, provides for both rotation and reciprocation such as the opening and closing of a valve.

Both of these flexible shafts may function in a continuous or intermittent operation with a minimum amount of vibration. They not only offer long lasting strength but also economies in cost, time and space.

Send for further details on how flexible shafting may be easily and economically incorporated into your design.

Write F. W. Stewart Corporation, 4311-13 Ravenswood Avenue, Chicago 13, Illinois.

Circle 419 on Page 19

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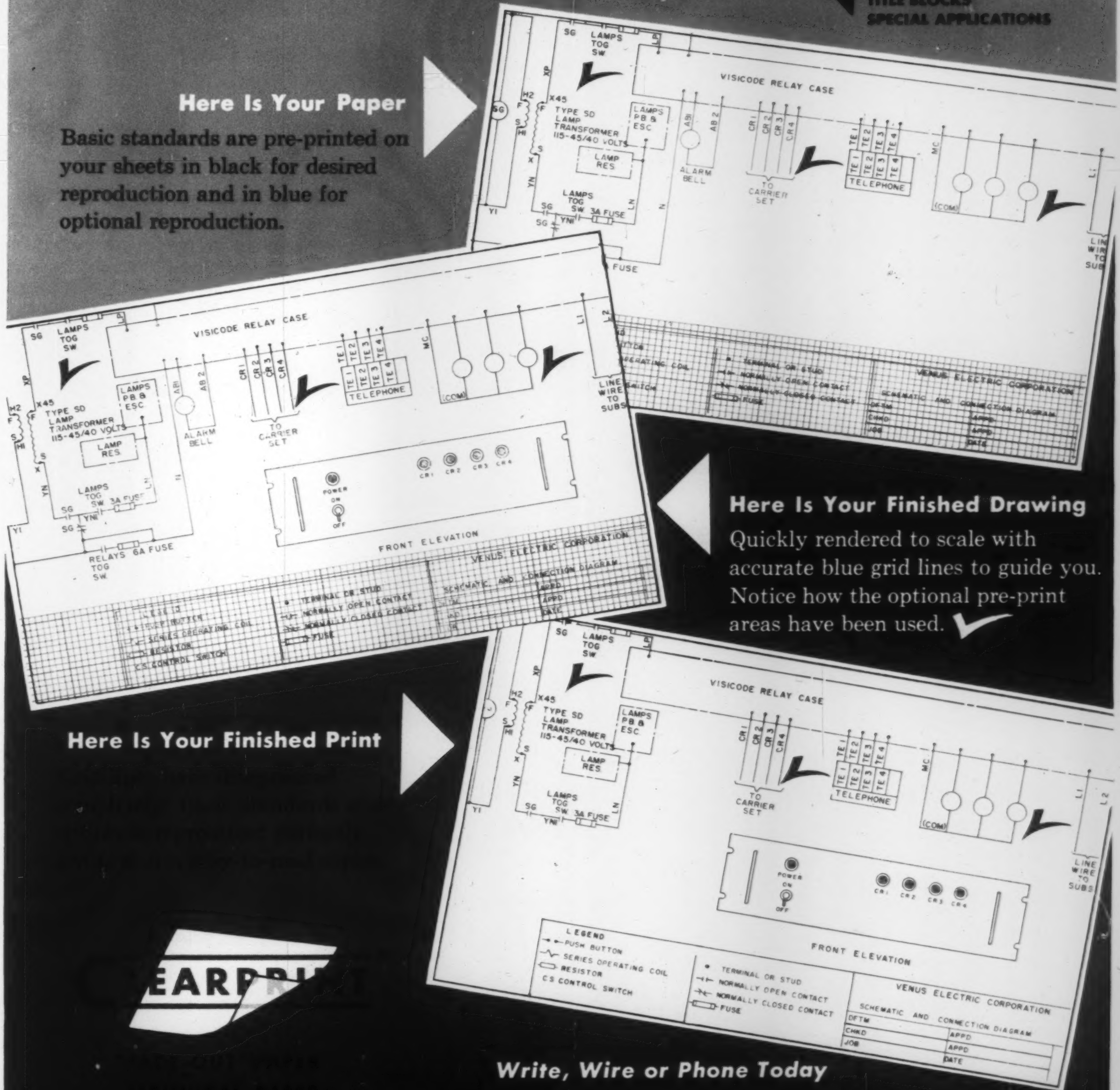

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Circle 420 on Page 19

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Air Traffic Keyboard Will Translate Flight Data

MINNEAPOLIS—A keyboard system will translate flight information and feed the data into electronic computers for use in the nation's air-traffic control modernization program. The unit is being developed by Control Data Corp. of Minneapolis under contract to the Civil Aeronautics Administration. Ultra-rapid handling of flight data will be an important part of the nation's advanced air-traffic control program, designed to meet ever-increasing airways activity.

Work calls for design and construction of a keyboard system which will enable air-traffic controllers to relay information received from planes to giant brains, which will then process the masses of flight data. The system will, in effect, translate the plain English of flight reports into the alphanumeric "language" of the computers. It will also allow the controller to view previously stored information.

Data handled via the keyboard will include position reports, changes of altitude, and airspeed and similar information from planes in flight.

In operation, the controller will punch out the information he receives from flying aircraft to an adding machine type of keyboard, using a combination of numerals and symbols. These information characters will then move into a static memory unit, which will hold them until the message is complete. At the same time, the complete message will be displayed on a translucent screen so that the operator can check it visually for accuracy.

When the *transmit* key is pushed, the entire message will be translated almost instantly and fed into the large computer. Checking circuits will guard against message error at each step of progress.

Automobile electrical failures caused more calls for help last year than any other car trouble, according to American Automobile Association. One out of every four cars in the U. S. had battery or ignition trouble. Flat tires, long the No. 1 headache, dropped to second place on AAA's list.

Circle 421 on Page 19

TEN SWITCHES PER SQUARE INCH is the remarkable space-saving possibility with this precision, snap-action unit developed by Minneapolis-Honeywell. Claimed to be the world's smallest, it measures 0.5 x 0.35 x 0.2 in. and weighs 1/28 oz. Electrical information: 5 amp at 250 v ac or 30 v dc; single-pole double-throw.

Warns U.S. Must Emphasize Automated Plant Techniques

Describes Soviet Organization For Modernizing Factories

DETROIT—Russian automation facilities and techniques will be superior to those of the United States by 1970, unless we place increased emphasis on building automatic factories, an American expert said recently. Nevin L. Bean of Ford's automatic transmission division told a session at the ASME semiannual meeting that, although Russian plants are not now as productive as those in this country, many adverse conditions are in process of being rapidly improved. "The engineering on some of the new automated lines being built would be a credit to an engineering group anywhere," he said.

In his opinion, Mr. Bean continued, the most important key to future Russian advances is an organization in Moscow called the Experimental Scientific Research Institute for Metal-Cutting Machine Tools (ENIMS). This organization considers its primary task is

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Circle 422 on Page 19

Maxitorq
Disc-pac...
the pre-packaged clutch or brake assembly
U.S. PAT. 2166130

Takes performance guesswork out of power transmission design

With these performance-proved units, you can save time and money in designing and building clutches and brakes exactly tailored to the requirements of your application. At the same time, you can be sure that they will equal the performance and smooth operation of proved MAXITORQ clutches and brakes. DISC-PACS are simply the "heart" of a clutch or brake . . . the discs, separator springs, and locking plate . . . supplied as a complete self-contained unit for the convenience of design engineers and equipment builders.

Produced in a full range of sizes and capacities from ¼ h.p. to 15 h.p. Bulletins available on other MAXITORQ products: Floating Disc clutches and brakes, Electric clutches, Overload Release clutches, low-cost Single Disc clutches, and clutch or brake friction discs. Write Dept. MD-7.

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preventing industries from building new units that do not incorporate the latest improvements, including automation. ENIMS controls the types of machines built, the uses to which they are put, and their distribution among various industrial plants. It strives for balanced design and plans tools at least five years in advance. Its experienced technicians read and analyze trade journals, especially those from the United States.

Hydrofoil Research Promises New Ocean Travel Concepts

Study "Sea Wings" for Use In 100 to 3000-ton Vessels

BETHPAGE, N. Y.—New concepts in ocean travel may be among the long-range results of a hydrofoil research program currently underway at Grumman Aircraft Engineering Corp. and Dynamic Developments Inc., both of Long Island, under contract to the Maritime Administration, U. S. Dept. of Commerce.

Although the use of hydrofoils in marine craft is not new, applications have been confined to small vessels. This study involves craft between 100 and 3000 tons, with range capabilities between 500 and 4000 nautical miles. Speeds for hypothetical vessels of this size and range capability could possibly be as high as 100 knots or more, according to Dynamic Developments Manager, William Carl. "Such a vessel—which we cannot even visualize today—would, by making an Atlantic crossing in approximately a day's time, completely revolutionize sea travel," he said.

Grumman's Leo Geyer, in charge of the study project, said that investigations included efforts to determine the cubic footage required per passenger on a vessel capable of a one-day ocean crossing. "Our 100-knot 'winged' vessel, by consuming more travel time than an airplane and less than the conventional vessel, will probably call for . . . passenger roomettes—quite similar to railroad facilities." As for the future, the Project Manager ventured a guess that tomorrow's hydro-

Circle 423 on Page 19

foil equipped ocean vessel "might resemble a submarine out of water," pointing out that high speeds would call for an all-enclosed type craft.

Defense Digest

Navy's fourth 75,000-ton carrier, the *Independence,* will be the last for time being. Congress has appropriated no funds for new carrier construction during the coming fiscal year, the first such omission since 1951. Two reasons are noted: Cost and vulnerability. The big Forrestal-class carriers are priced at $200 million, minus planes; carry more than 4000 men plus 100 planes. This is too many eggs in one basket and a duplication of Air Force effort, according to congressional critics, who favor less vulnerable submarine-missile combination for the Navy.

• • •

Dyna-Soar, the Air Force's advanced boost-glide aircraft, is entering the development stage with two contractors—Martin Co. and Boeing Airplane Co. Air Force, NACA, and aircraft industry have been gathering and assessing data on the boost-glide or dynamic soaring concept since 1951. Present knowledge indicates that the vehicle will have capabilities for variety of missions, since it can orbit by skipping along the "surface" of the atmosphere and will have aerodynamic lift and pilot control for flight at lower altitudes.

• • •

Simple home warning system developed for civil defense consists of a small electronic device that plugs into 110-v outlet. At warning of attack or natural disaster, the alarm receiver is triggered by brief, controlled signals transmitted over regular power network. Listeners, alerted by a loud buzzing, would tune in TV or radio for instructions. Trial units are being installed near Battle Creek, Mich., by Consumers Power Co. and Midwest Research Institute.

• • •

Remote-controlled amphibious landings are being carried out by Marines in a surf-testing program for amphibious vehicles. A complete assault force of LVT's (Landing Vehicle, Tracked) is directed through rugged seas by radio from a hovering helicopter. The new testing program accomplishes its mission without endangering Marine lives.

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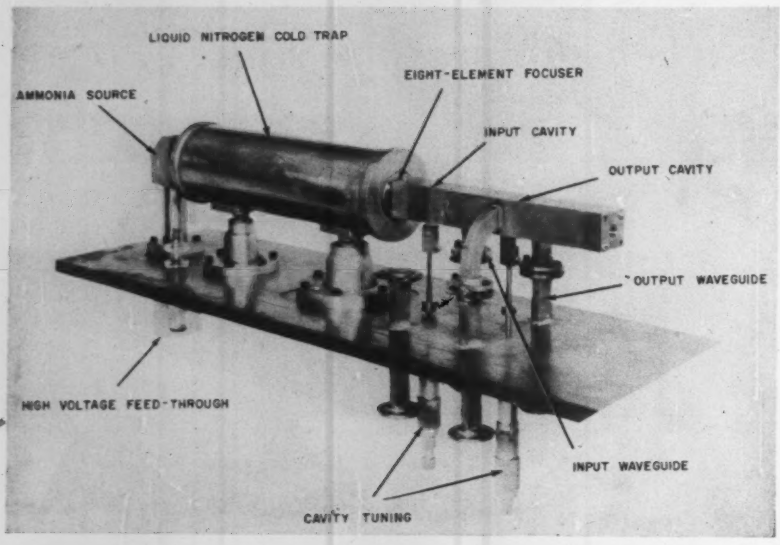


ATOMIC AMPLIFIER is the designation given by Philco Corp. to their new gas maser. It is the first to demonstrate unilateral (one-way) gain in microwave energy by means of two electrically isolated cavities connected only by a beam of neutral ammonia gas molecules. As the oscillating molecules pass through the second cavity, electromagnetic radiation is developed and appears in the output waveguide. This provides unilateral amplification without aid of electronic effects. Masers have the virtue of providing amplification free from extraneous noises inherent in electronic circuitry.

Meetings

AND EXPOSITIONS

Aug. 6-8—

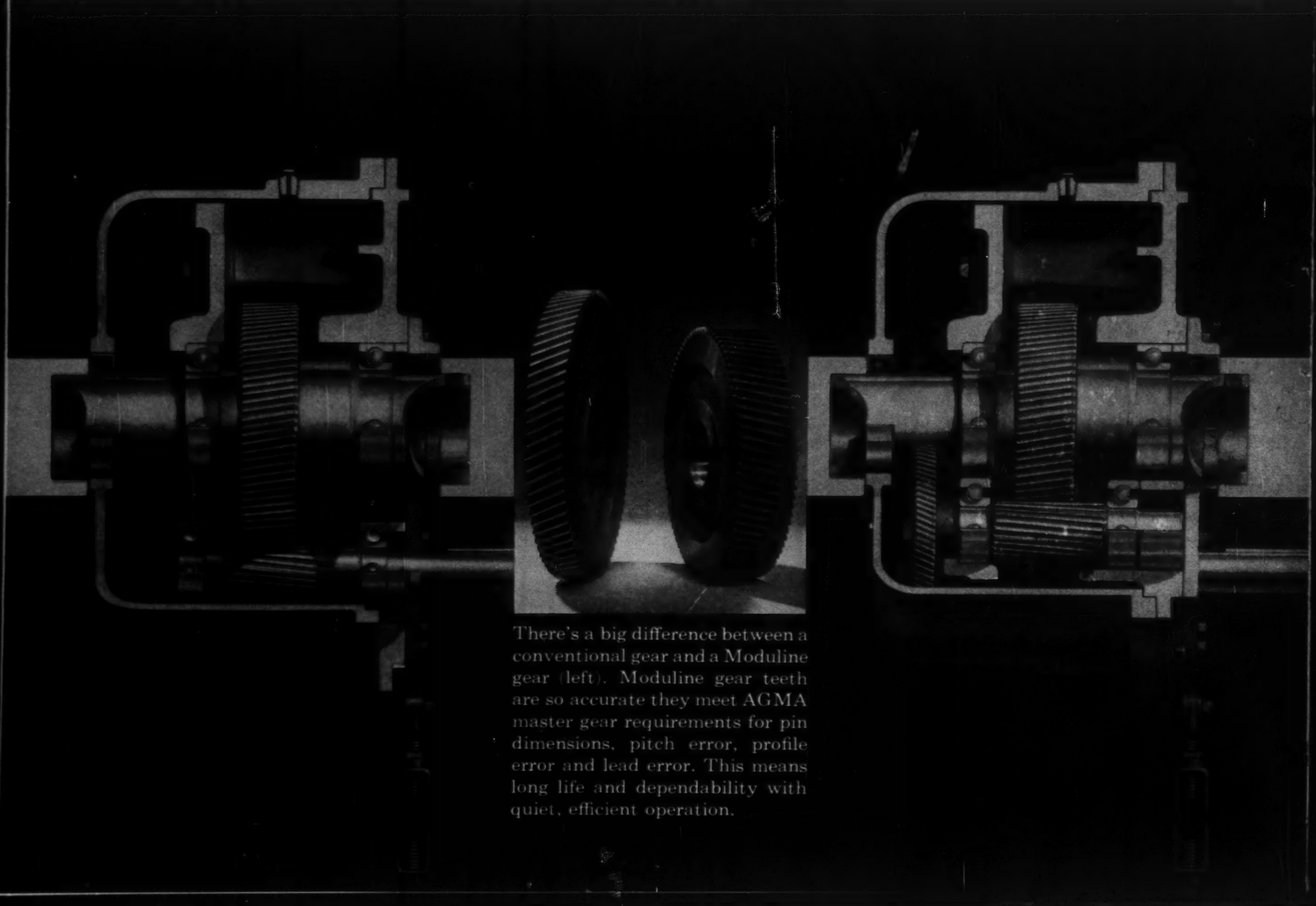
American Institute of Electrical Engineers. 1958 Special Technical Conference on Nonlinear Magnetics and Magnetic Amplifiers, to be held at the Hotel Statler, Los Angeles. Additional information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Aug. 11-13—

Western Packaging and Materials Handling Exposition to be held at the Civic Auditorium, San Francisco. Further information is available from Clapp and Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Aug. 13-15—

Conference on Electronic Standards and Measurements to be held at the National Bureau of Standards' Boulder, Colo., laboratories. Sponsors are the American Institute

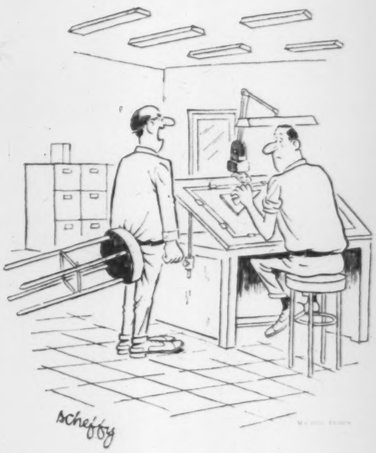

There's a big difference between a conventional gear and a Moduline gear (left). Moduline gear teeth are so accurate they meet AGMA master gear requirements for pin dimensions, pitch error, profile error and lead error. This means long life and dependability with quiet, efficient operation.

of Electrical Engineers, the Institute of Radio Engineers, and the NBS. Further information is available from U. S. Dept. of Commerce, National Bureau of Standards, Washington 25, D. C.

Aug. 18-21—
American Institute of Chemical Engineers—American Society of Mechanical Engineers. Heat Transfer Conference to be held at Northwestern University, Evanston, Ill. Additional information is available from AICE headquarters, 25 W. 45th St., New York 36, N. Y.

Aug. 19-22—
Western Electronic Show and Convention to be held at the Ambassador Hotel and Pan Pacific Auditorium, Los Angeles. Sponsors are the West Coast Electronic Manufacturers Association and the Institute of Radio Engineers. Further information is available from Don Larson, WESCON, 1435 S. La Cienga Blvd., Los Angeles 35, Calif.

Sept. 3-5—
First National Conference on the Application of Electrical Insulation to be held at the Pick-Carter and Statler-Hilton Hotels, Cleveland. Cosponsors are the American Institute of Electrical Engineers and the National Electrical Manufacturers Association. Further information can be obtained from T. F. Hart, Silicones Div., Union Carbide Corp., 30 E. 42nd St., New York 17, N. Y.

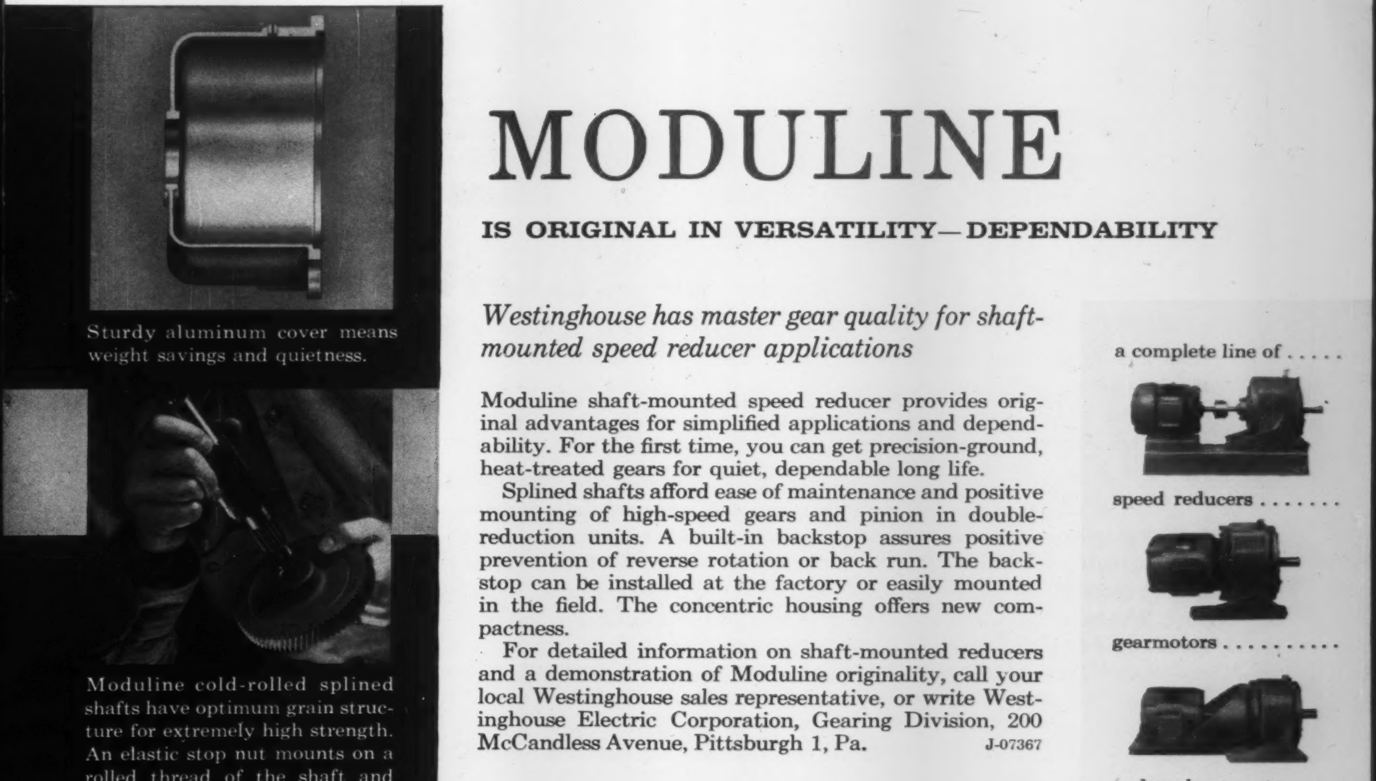


"I found your chewing gum."

Sept. 8-13—
Institute of the Aeronautical Sciences. First International Congress of the International Council of the Aeronautical Sciences to be held at the Palace Hotel, Madrid, Spain. Further information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Sept. 14-18—
American Rocket Society. Fall meeting to be held at the Statler Hotel, Detroit. Further information is available from ARS headquarters, 500 Fifth Ave., New York 36, N. Y.

Sept. 14-19—
Instrument Society of America. Thirteenth Annual Instrument-Automation Conference and Exhibit to be held at Convention Hall, Philadelphia. Additional information is available from society headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.



Sturdy aluminum cover means weight savings and quietness.

Moduline cold-rolled splined shafts have optimum grain structure for extremely high strength. An elastic stop nut mounts on a rolled thread of the shaft and holds gears and pinions in place axially. These splined shafts assure accurate alignment and serviceability.

MODULINE

IS ORIGINAL IN VERSATILITY—DEPENDABILITY

Westinghouse has master gear quality for shaft-mounted speed reducer applications

Moduline shaft-mounted speed reducer provides original advantages for simplified applications and dependability. For the first time, you can get precision-ground, heat-treated gears for quiet, dependable long life.

Splined shafts afford ease of maintenance and positive mounting of high-speed gears and pinion in double-reduction units. A built-in backstop assures positive prevention of reverse rotation or back run. The backstop can be installed at the factory or easily mounted in the field. The concentric housing offers new compactness.

For detailed information on shaft-mounted reducers and a demonstration of Moduline originality, call your local Westinghouse sales representative, or write Westinghouse Electric Corporation, Gearing Division, 200 McCandless Avenue, Pittsburgh 1, Pa. J-07367

a complete line of .....

speed reducers ....

gearmotors ....

and package motor reducer drives ....

POWER-UP!
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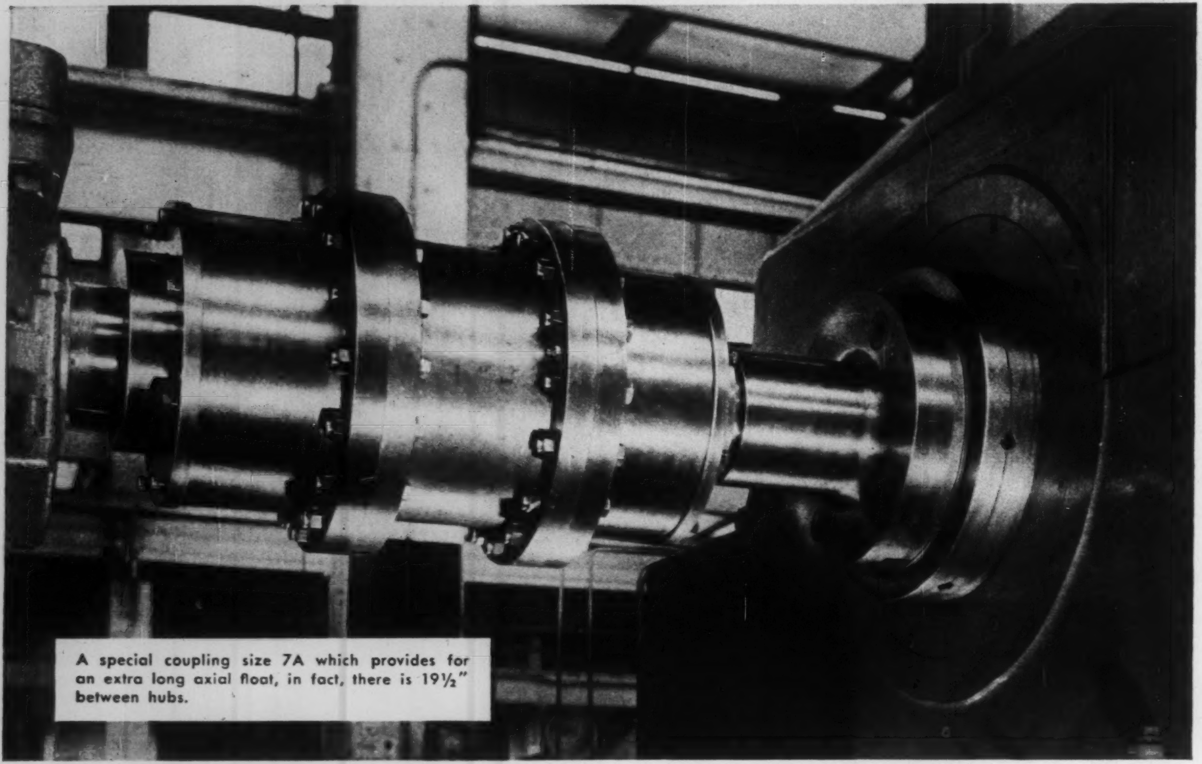
Circle 425 on Page 19

SPECIAL COUPLING PROBLEMS



A special coupling size 7A which provides for an extra long axial float, in fact, there is 19½" between hubs.

SOLVED

at JOHN WALDRON

From time to time, manufacturers are faced with special power transmission problems which cannot be handled by standard couplings. Sometimes they need a coupling for exceedingly high speed drives, sometimes a coupling for very large diameter shafts and for other special applications.

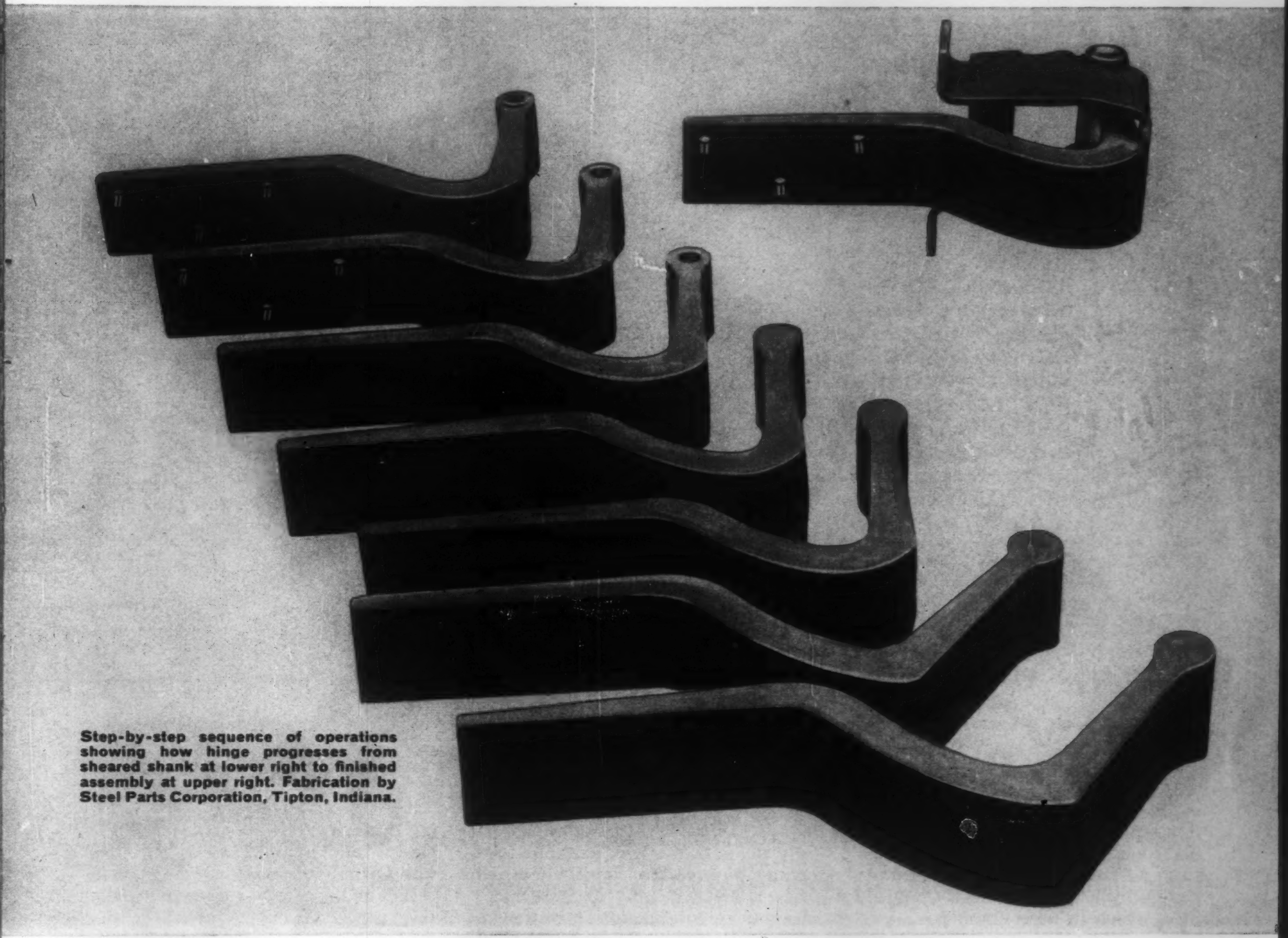
John Waldron, which is well known for its ability to produce high quality couplings also makes excellent special couplings to customer requirements. In the past, Waldron has made couplings that turn at speeds over 50,000 RPM, couplings which can take over 45,000 HP and couplings for particular applications such as continuous lubricated couplings, spacer types, shear pins, cut-outs and couplings for many other special installations.

If you have a particular power transmission problem that needs a special coupling, call or write the John Waldron Corporation in New Brunswick, New Jersey. Their long experience in designing, and manufacturing couplings for special problems, may have already solved your problem for you.

JOHN **WALDRON** CORP.
A unit of J. O. Ross Engineering Division
Midland-Ross Corporation
New Brunswick, New Jersey

Circle 426 on Page 19

STEEL SHAPED TO CUT COSTS AND IMPROVE PRODUCTS



Step-by-step sequence of operations showing how hinge progresses from sheared shank at lower right to finished assembly at upper right. Fabrication by Steel Parts Corporation, Tipton, Indiana.

Auto door hinges made quickly . . . from steel already rolled to shape!

USS Special Section rolled to approximate dimensions of door hinge.

Hinges by the hundreds can be quickly sliced from these USS Special Section Rolled Steel Bars. Then, with a few bending, milling and drilling operations, the hinge is ready for final assembly.

This is a fast, low-cost method for producing an irregular part. There's very little machining, and scrap losses are practically eliminated. By no other method can parts like these be produced so speedily, so economically, and so strong.

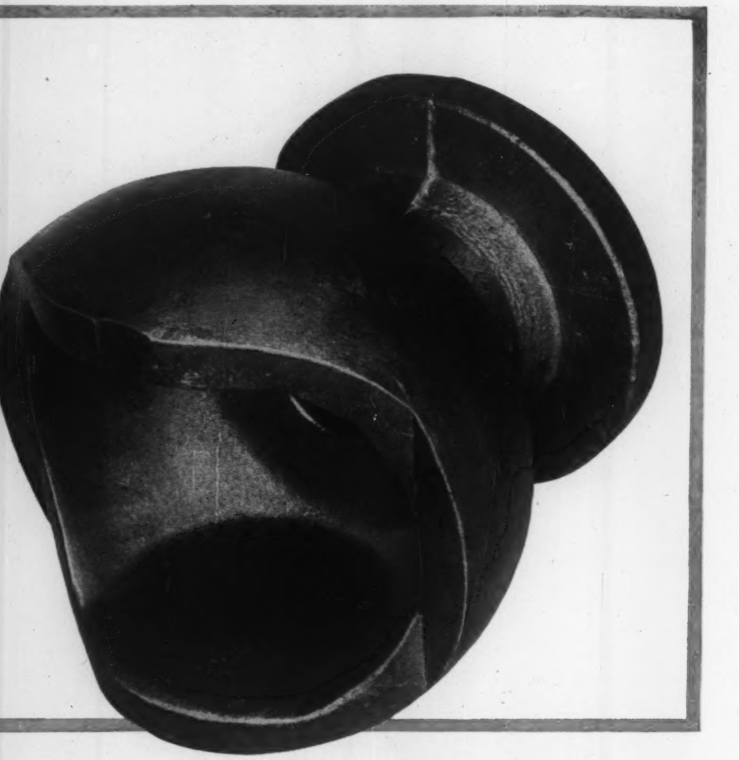
Why not find out what USS Special Sections can do for you? If you are producing large quantities of parts that require extensive machining—or must be forged or cast—this method may save you money. For more information, write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

United States Steel Corporation – Pittsburgh
Columbia-Geneva Steel – San Francisco
Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Export Company

USS TRADEMARK **United States Steel**

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

unusual design in upset forging...



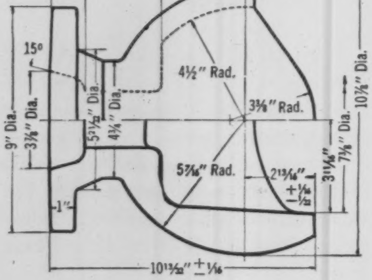
BALL-JOINT HOUSING for the steering and driving mechanism of the Clark Equipment Company's line of Four-Wheel Drive MICHIGAN End Loaders and Turbo-Dozers formerly produced as a steel casting is now turned out by Commercial as a closed-die forging on an 8-inch upsetter.

80 lb. forging replaces 95 lb. casting

A saving of 15 lbs. of metal on each housing component is only part of the impressive cost cutting story made possible at Clark Equipment Company by a switch to upset forgings.

When the parts were produced by Commercial as closed-die forgings on an 8-inch upsetter Clark Equipment reported:

1. An initial cost saving of 90¢ per part.
2. Closer tolerances for a 10% machining cost saving.
3. No rejects due to hidden metal defects.



UNUSUAL SHAPE and characteristics notwithstanding — flanged on one end, belled on the other, and open on both ends—Commercial engineers proved this part could be produced as an upset forging with greater cost savings.

Now, this important component not only costs Clark less per unit, but because of its controlled grain flow and efficient metal distribution it provides maximum tensile and torsional strength to resist unusual operating strains as well as massive and unpredictable shock and load. Longer operating life and trouble-free performance are assured.

And because forging impact and pressure produces a more dense, more uniform metal structure, forged parts absorb and dissipate heat at a uniform measurable degree. Obviously, that means elimination of distortion problems in heat treating. It also means fewer rejects during machining, since this dense uniform forged metal has no hidden internal flaws.

With new forging techniques continually unfolding to meet specific job requirements, more original equipment manufacturers are increasingly looking to upset forging to help solve their component forming problems—stronger, lighter, more compact parts at less cost per unit.

Many parts like this unusually shaped housing for Clark Equipment, which were formerly considered impossible to forge, are now routine at Commercial. An early check with Commercial's forging engineers on your particular component forming problem may pave the way for improvement in your product design and production methods—could save you time, money, and help improve performance and operating life.

WHEN AN UPSET FORGING?

Check your part forming problems against this list of "bench marks" for parts requiring:

- Reduced weight, thinner section, greater strength.
- Consistent soundness — no losses due to porosity.
- Good appearance—smooth, close-grained surface.
- Superlative shock and fatigue resistance.
- Uniform response to heat treatment.
- Cost-cutting advantages in finishing—less waste metal, reduced machining, no rejects due to hidden flaws.

Address The Commercial Shearing and Stamping Company, Dept. S-28,
Youngstown 1, Ohio.

COMMERCIAL
shearing and stamping

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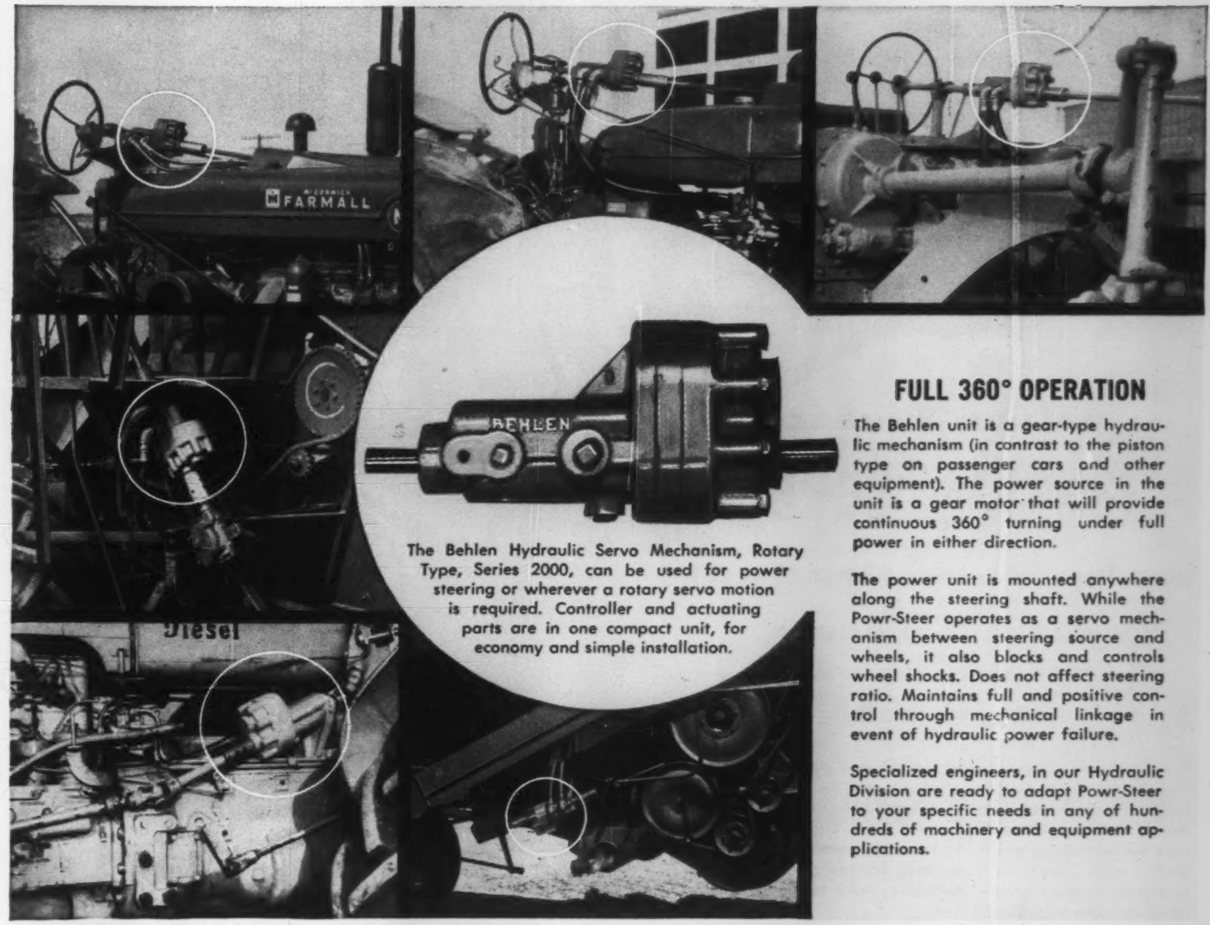


The Behlen Hydraulic Servo Mechanism, Rotary Type, Series 2000, can be used for power steering or wherever a rotary servo motion is required. Controller and actuating parts are in one compact unit, for economy and simple installation.

FULL 360° OPERATION

The Behlen unit is a gear-type hydraulic mechanism (in contrast to the piston type on passenger cars and other equipment). The power source in the unit is a gear motor that will provide continuous 360° turning under full power in either direction.

The power unit is mounted anywhere along the steering shaft. While the Powr-Steer operates as a servo mechanism between steering source and wheels, it also blocks and controls wheel shocks. Does not affect steering ratio. Maintains full and positive control through mechanical linkage in event of hydraulic power failure.

Specialized engineers, in our Hydraulic Division are ready to adapt Powr-Steer to your specific needs in any of hundreds of machinery and equipment applications.

Increased production catching up with demand:

Behlen

HYDRAULIC SERVO MECHANISM

Rotary Gear-Type Power Steering

This Behlen unit is now available for more original equipment manufacturers of:

Farm tractors
Combines
Fork-lift trucks
Motor graders
Motorized Cranes
Tractor shovels

. . . and all similar industrial, heavy construction and agricultural equipment applications . . . wherever a perfected rotary servo-motion power assist can reduce the need for muscle-power and manpower.

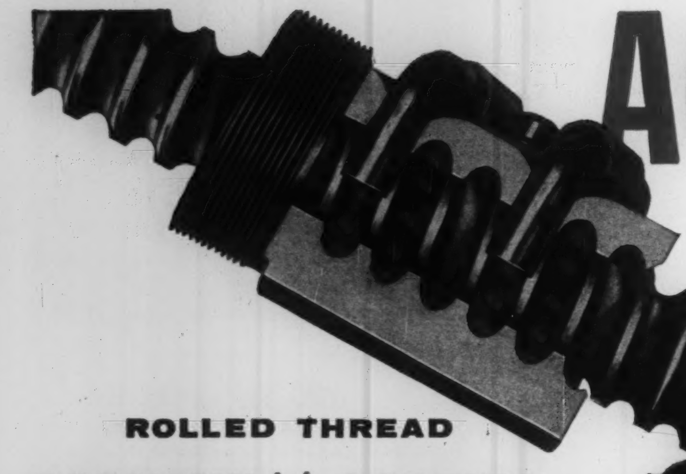
The Behlen Hydraulic Servo Mechanism was introduced six years ago as a field-installed power steering unit for row crop tractors. Soon thousands of farmers were enjoying the ease and safety of Behlen Powr-Steer, applied to tractors of nearly every make and model. International Harvester adopted it as original equipment on their Farmalls 300 and 400 series. Other manufacturers of self-propelled equipment quickly followed — at a pace that outstripped our production capacity.

Recently we completed a big plant expansion program. Now we're ready to supply the Behlen Hydraulic Servo Mechanism on a scale and schedule to meet your needs.

We want you to see how easily the mechanism can be applied to your products as original equipment, and how it can add a big plus to the sales appeal. Get in touch with us now.

Phone, write or wire Howard Christenson, production manager
BEHLEN MANUFACTURING COMPANY • Dept. DM-7 • Columbus, Nebraska
World's largest manufacturer of tractor and grader power steering

Circle 428 on Page 19



ACTUATE

MORE EASILY . . .
EFFICIENTLY . . .
ECONOMICALLY

ROLLED THREAD

SAGINAW b/b SCREWS

Make Your Product

- **easier to produce**
- **easier to operate**
- **easier to sell**

The secret lies in a new anti-friction principle—steel balls recirculating in closed-circuit raceways. They permit Saginaw b/b Screws to change rotary motion into linear motion with over 90% efficiency and 4/5 less torque than Acme screws. Result: Saginaw b/b Screws save manual effort or electrical power; they permit space savings—smaller motors and gear boxes; they provide more dependable performance; more precise positioning; more temperature tolerance and more lubrication latitude.

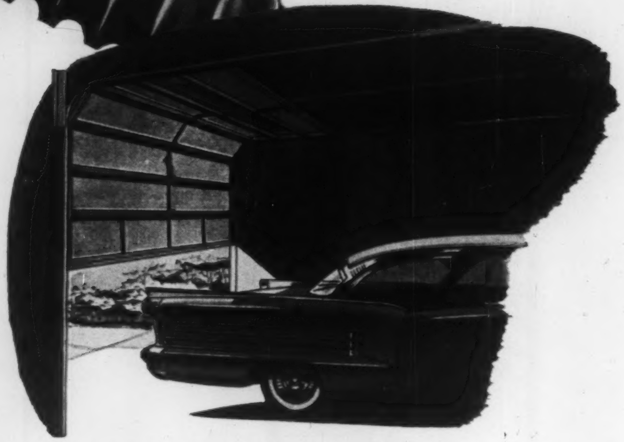
SEVEN STANDARD SIZES REDUCE COSTS

Top-quality Saginaw b/b Screws are the only kind stocked in seven standard commercial rolled thread sizes, cut to desired length, for low cost and fast delivery. Or you can order custom machined screws for critical or extreme precision applications. Saginaw has successfully built screws from 1½ inches to 39½ feet long—⅜ inches to 10 inches diameter.

MANY TYPICAL APPLICATIONS

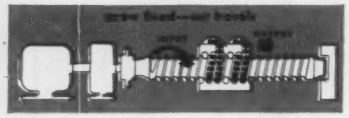
Saginaw b/b Screws have been applied to automatic garage doors, automobile seat adjusters and window lifts, barber chairs, hospital beds, bumper jacks and circuit breakers. Or they can be used for heavy industry equipment like die table positioners, drill presses, lift trucks and welders.

FREE ENGINEERING HELP FOR YOUR SPECIAL APPLICATION



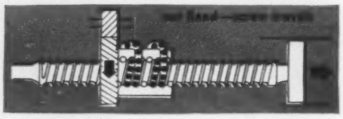
Automatic Garage Door lifts and lowers easily and smoothly when actuated by Saginaw b/b Rolled Thread Screw.

HOW THE WORLD'S MOST EFFICIENT ROTO-LINEAR DEVICE WORKS



When rotary motion is applied to the screw, the b/b nut is driven along the axis of the screw, changing rotary motion to linear motion with over 90% efficiency.

When rotary motion is applied to the b/b nut, the screw is driven along its longitudinal axis, changing rotary motion to linear motion with over 90% efficiency.



LET SAGINAW'S EXPERIENCED ENGINEERS HELP SOLVE YOUR SPECIAL APPLICATION PROBLEMS . JUST WRITE OR PHONE US—NO OBLIGATION

Saginaw
ball/bearing Screw

SAGINAW STEERING GEAR DIVISION • GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN

Circle 429 on Page 19

Heat dissipation front and back

Adjustable stops

Wear-resistant contacts

VOLTS
SPEED
RESET

Stable operation, hour after hour

FOUR REASONS WHY

G-E rheostats give top performance at low cost

General Electric plate rheostats offer many outstanding features to give you the best possible performance with minimum cost and maintenance. These features include:

Greater heat dissipation—completely metal-encased and cement-filled rheostat dissipates heat from both sides. This allows a smaller, lower-cost rheostat to be used for a given rating.

Easily adjustable stops—two movable stops can be set to predetermine the range of operation of the G-E rheostat.

Less contact wear—the movable contact rides on special wear-resistant segments, not on the resistance wire. This substantially increases the operating life of the rheostat.

Stable operation—once the rheostat is set on the desired rating, it will maintain that setting with negligible change in resistance, resulting in dependable "set-and-forget" operation.

Act now! You can get G-E rheostats in six-, nine- or twelve-inch sizes, dissipating as high as 1100 watts per plate.

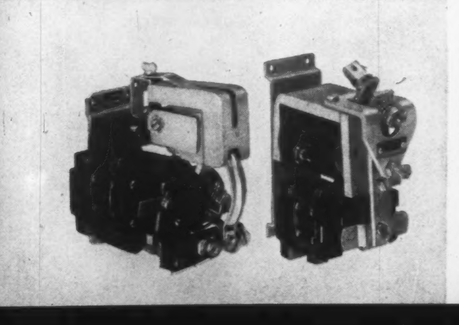
NEED OTHER COMPONENTS?

General Electric also has complete lines of contactors, relays and resistors for all your control needs. For more information, contact your G-E Sales Engineer or mail this coupon today! Industry Control Dept., Roanoke, Va.

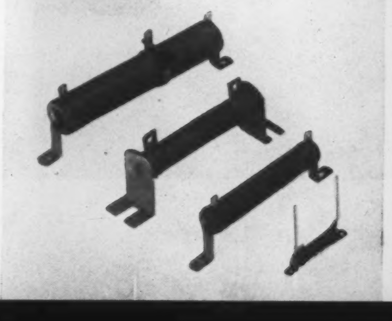
GENERAL ELECTRIC

Circle 430 on Page 19

D-c contactors and relays—feature new "building-block" construction to give maximum flexibility with minimum inventory.



Vitreous-enameled resistors—1070 ohmic values from stock, fixed or slide wire, 5 to 200 watts. Call your G-E representative.



To: Section A784-14
General Electric Co.
Schenectady 5, N. Y.

Please send the following bulletins:

- ☐ **GEA-6474—Plate-type rheostats**
- ☐ **GEA-6592—Vitreous-enameled resistors**
- ☐ **GEA-6621—D-c contactors and relays**

Name ____________________

Company ____________________

Address ____________________

City ____________________ **State** __________

ELECTRONIC and ULTRASONIC quality control of MUELLER rod, tube, fabricated parts and

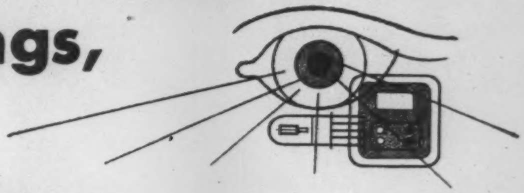
Every practical electro-mechanical testing device available to industry today is used by the Mueller Brass Co. to maintain Positive Quality Control during each manufacturing operation. From the first stages of alloying, spectroscopic analysis is used to maintain exact alloy composition so that they are precisely as specified. Ultrasonic test equipment is utilized in the non-destructive testing of extruded brass and bronze rod, copper tube, forgings and fabricated parts. In machining and finishing operations, statistical quality control is employed to eliminate the effect of possible human error. These quality controls are all designed for one purpose . . . to give you complete "product protection."

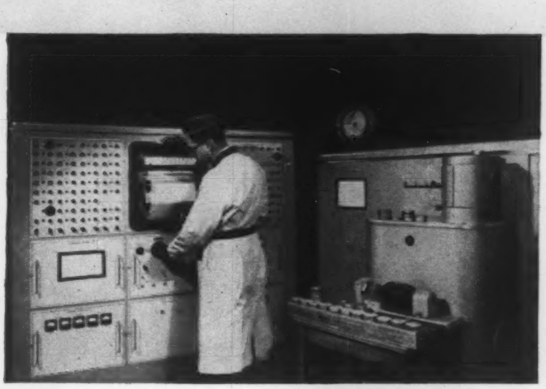
•

Copper base alloy rod is examined by a trained operator with the aid of an ultrasonic reflectoscope. Through electronic circuitry, ultrasonic echoes are translated on a cathode ray tube. Any internal flaws are readily apparent. Both rod and tube are tested by this method, which is just one of many Positive Quality Control checks used by the Mueller Brass Co.

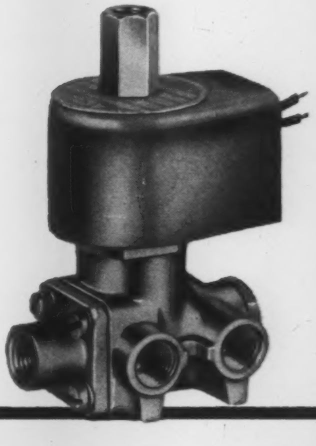
Through ultrasonics, the immerscope (Left) locates internal defects, and has exceptional versatility for examining intricately shaped parts, such as the forging being checked in this photo. When testing, a transducer, located at the bottom end of the search tube, is electronically actuated to produce from 2.2 to 25 million cycles per second. Ultrasonic echoes are reflected back to the transducer from the material, indicating any defects that may be present. Limits may be pre-established and the sound findings are visually recorded on the cathode tube. This is another instance of Positive Quality Control in action.

TESTING helps insure positive BRASS CO. forgings, assemblies . . .

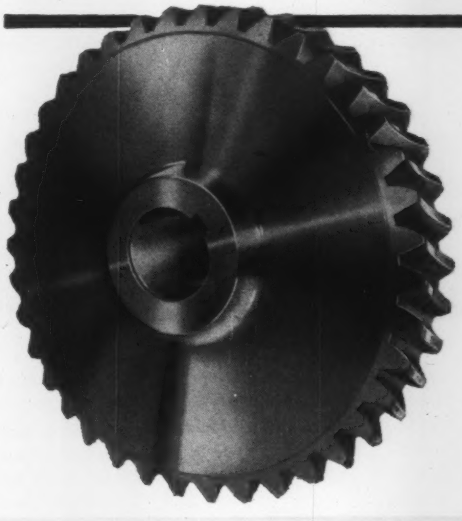




The direct reading spectrometer (Left) makes it possible to accurately analyze an alloy for chemical composition within 90 seconds while the metal is in the molten stage. A sample specimen is poured, cooled and sent to the laboratory, where it is placed in the spectrometer. Through the diffraction gratings in the machine, the "spectrum" analysis of the alloy records its exact chemical composition. With this equipment, alloy specifications are matched exactly, thus insuring a better finished product through Positive Quality Control.

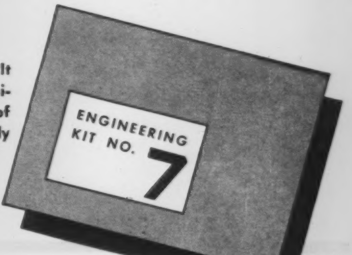


THIS MIDGET 4-WAY SOLENOID VALVE (Right) is one of a complete line designed and manufactured by the Automatic Switch Co. (ASCO) of Florham Park, New Jersey. Valves of this type are used for controlling small double acting cylinders which operate valves, dampers and many types of automatically controlled equipment. One of the most important components in these valves is the non-porous brass body forged by the Mueller Brass Co. who also perform all the major machining operations so that the body is ready for use upon delivery. The forged brass body insures freedom from porosity and reduces possibility of corrosion. The Mueller Brass Co. Positive Quality Control program insures ASCO complete "product protection". . . and eliminates chance of "in-service" failures.



THIS LARGE 18" FORGED GEAR, along with two others of the same type, is used in a steam turbine installed in a power generation facility of the Wisconsin Electric Power Company, at Port Washington, Wisconsin. The gear was forged in open dies by the Mueller Brass Co. from tough, long-wearing 603 alloy. The gear operates at 25-30 RPM and is turned by the turbine, which has a capacity of 80,000 kilowatts. Strength and dependability are of utmost importance in applications like this, and in such cases Positive Quality Control insures peak performance.

Write for your engineering kit no. 7. It contains complete laboratory and engineering data plus typical examples of Mueller Brass Co. products used in widely diversified applications.



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MUELLER BRASS CO. PORT HURON 20, MICHIGAN

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LAKE ERIE
DANGER
WARNING

PLANT...North American Aviation

PROCESS...Hot Press Forming

OPERATING TEMPERATURE...Titanium @ 1000°F.

HAZARD...Line Break

Hydraulic Fluid Used...FIRE RESISTANT CELLULUBES

To assure maximum safety in the operation of a specially developed hydraulic press for form-die quenching, North American Aviation uses Cellulube 220 fire-resistant synthetic fluid.

During the process, fully expanded parts, @ 1000° F, are transferred from a nearby electric furnace to the press for hot-forming aircraft parts made with high-strength alloys.

Cellulube . . . the *safe* hydraulic fluid . . . is available in six controlled viscosities. One of them is best suited to your purposes and to the safety of your plant and personnel. So, for safety's sake, investigate Cellulubes. We will be glad to supply the information you want. If you'd like to have a sample, please let us know the application involved.

Celanese® Cellulube®

Cellulube . . . a Celanese CHEMICALS fire-resistant functional fluid

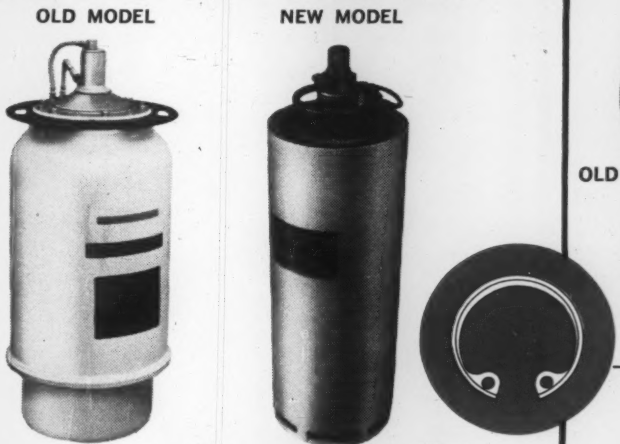
Celanese Corporation of America, Chemical Division, Dept. 545-G, 180 Madison Avenue, New York 16, N. Y.

Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, New York 16, N. Y.

Circle 432 on Page 19

2 Giant Waldes Truarc Beveled Rings Cut Costs $500, Save 76½ Hours Machining-Assembly Time on X-Ray Unit

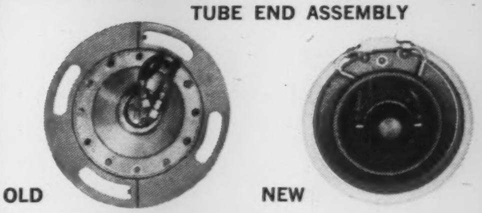
TRIPLETT & BARTON TRI-IND-X PORTABLE X-RAY UNIT



	OLD SPECIFICATIONS	NEW SPECIFICATIONS
Weight	107 lbs.	65 lbs.
Diameter	15 inches	11 inches
Machining and Assembly Time	78 hours	1½ hours
Service Time	4½ hours	5 minutes
Parts	27 bolts	2 Truarc Rings

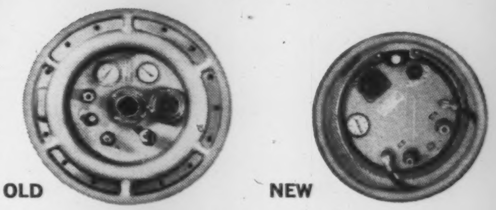
Prior to adoption in their new bantam-weight TRI-IND-X, Triplett & Barton, Inc., Burbank, Calif., subjected Waldes Truarc Retaining Rings to severe tests and rigid inspections. Although the TRI-IND-X operates at a normal pressure of 50 psi, Truarc Rings were subjected to pressure tests in excess of 500 psi, proving their high performance.

TUBE END ASSEMBLY



ONE 10" BEVELED RING REPLACES 12 BOLTS—Machining and assembly time formerly required 78 hours . . . now reduced to 1½ hours! Service operations for dismantling or tube change formerly required 4½ hours . . . now reduced to 5 minutes! In addition to savings on materials, costs have been reduced approximately $500 per unit.

END BELL ASSEMBLY



ONE 9" BEVELED RING REPLACES 15 BOLTS—In addition to functioning as mechanical fasteners, the Truarc Beveled rings serve as pressure vessel closures, providing leak-proof seals. The wedge action of the ring compensates for wear, provides a constant tight seal.

Whatever you make, there's a Waldes Truarc Ring designed to save you material, machining and labor costs, and to improve the functioning of your product.

In Truarc, you get

Statistically Controlled Quality from engineering and raw materials to the finished product. Every step in manufacture watched and checked in Waldes' own modern plant.

Complete Selection: 36 functionally different types. As many as 97 standard sizes within a ring type. 5 metal specifications and 14 different finishes. All types available quickly from leading OEM distributors in 90 stocking points throughout the U. S. and Canada.

Field Engineering Service: More than 30 engineering-minded factory representatives and 700 field men are at your call.

Design and Engineering Service not only helps you select the proper type of ring for your purpose, but also helps you use it most efficiently. Send us your blueprints today . . . let our Truarc engineers help you solve design, assembly and production problems . . . without obligation.

WALDES
TRUARC®
RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, N. Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C. 1, N.Y.

Please send new, descriptive catalog showing all types of Truarc rings and representative case history applications.

(Please print)

Name____________________

Title____________________

Company____________________

Business Address____________________

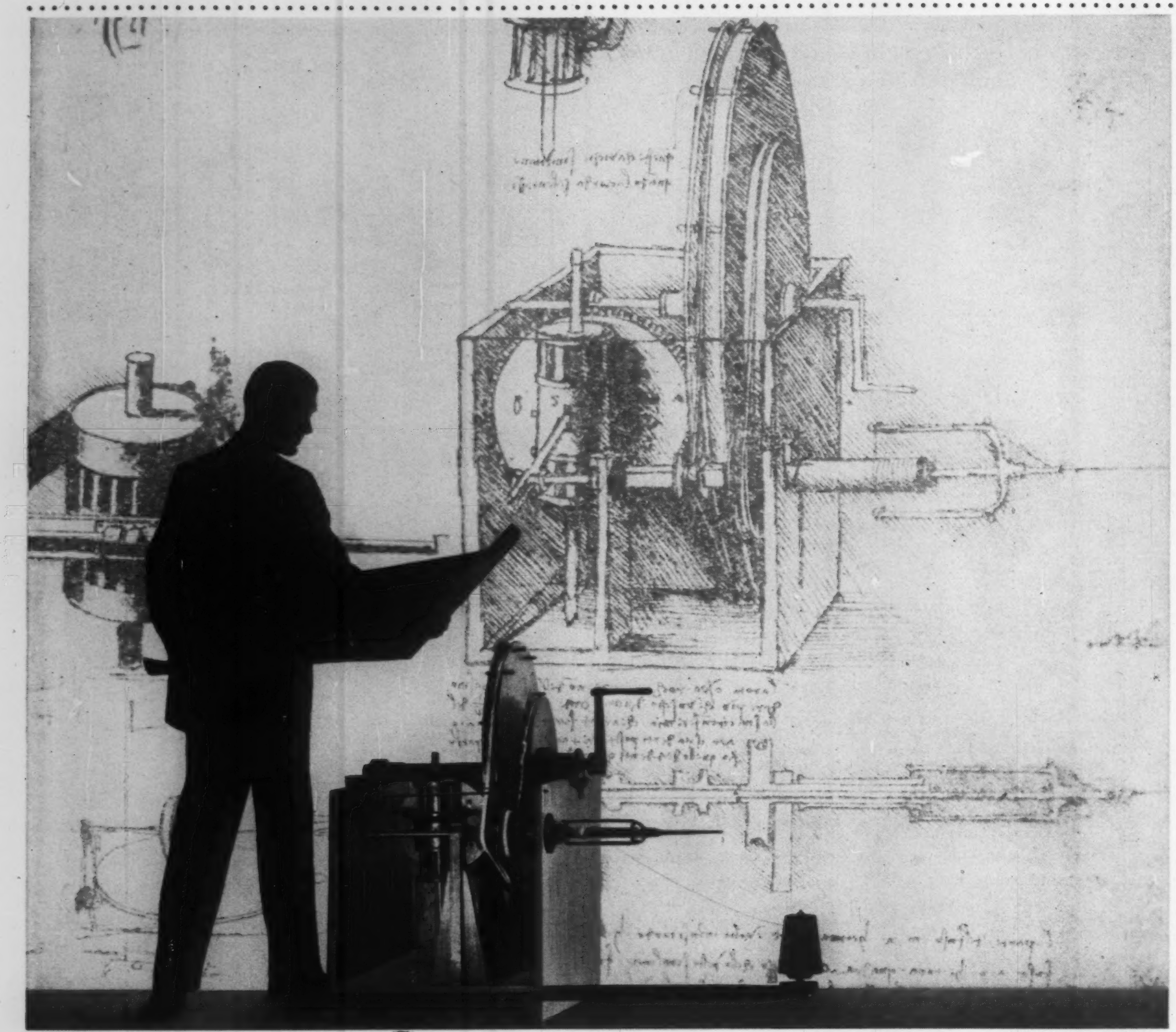
City__________ Zone_____ State__________

MD 070

Consult the Yellow Pages of Your Telephone Directory for Name of Local Truarc Factory Representative and Authorized Distributor. Look under "Retaining Rings" or "Rings, Retaining."

Circle 433 on Page 19

creative designing calls for an open mind



Leonardo Da Vinci's design for a flyer spindle for a loom

Model courtesy of IBM

EVEN DA VINCI'S DESIGN COULD HAVE BEEN BETTER WITH HELP FROM AN SKF ENGINEER—An SKF engineer never has to push one bearing over another, because SKF makes all four types of ball and roller bearings in over 3,000 sizes. This gives every SKF engineer the kind of flexibility he needs to keep an open mind on *any* bearing problem. Give your problem to SKF and see.

7812

Spherical, Cylindrical, Ball, and Tyson Tapered Roller Bearings

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

®REG. U.S. PAT. OFF.

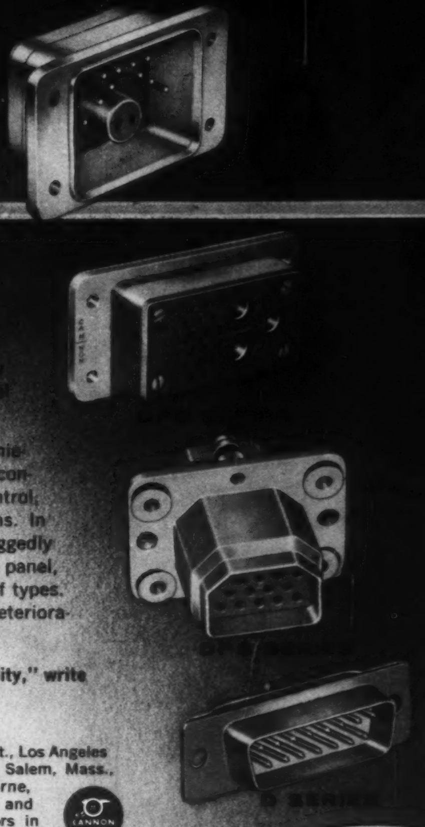
H. J. Bärschel

RELIABLE

Rack-Panel-Chassis Connectors

for RAPID DISCONNECT

Faster Inspection...Faster Testing...
Faster Servicing...Maximum Interchangeability



Cannon offers you more than 18 different basic designs in rack-panel-chassis connectors...designed with all the latest features to give you accurate alignment, easy mating, proper connection, and interfacial sealing where desired.

Select the connector you want in standard, miniature, or sub-miniature sizes...for standard circuitry or printed circuitry. Up to 156 contacts...and a great number of combinations of contacts for control, audio, thermocouple, co-ax, twin-ax, and pneumatic connections. In single- or double-gang. Some with shells, some without...all ruggedly constructed to take the many "in" and "out" operations of rack, panel, chassis, and sub-assembly applications. Special moisture-proof types. Standby units featuring gold-plated contacts to withstand deterioration and corrosion.

For an interesting discussion of the broad subject of "Reliability," write for Cannon Bulletin R-1.

DP RTC
CANNON

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, California. Factories in Los Angeles, Salem, Mass., Toronto, Can., London, Eng., Melbourne, Austl. Manufacturing licensees in Paris and Tokyo. Representatives and distributors in all principal cities. **Please refer to Dept. 186.**

CANNON ELECTRIC

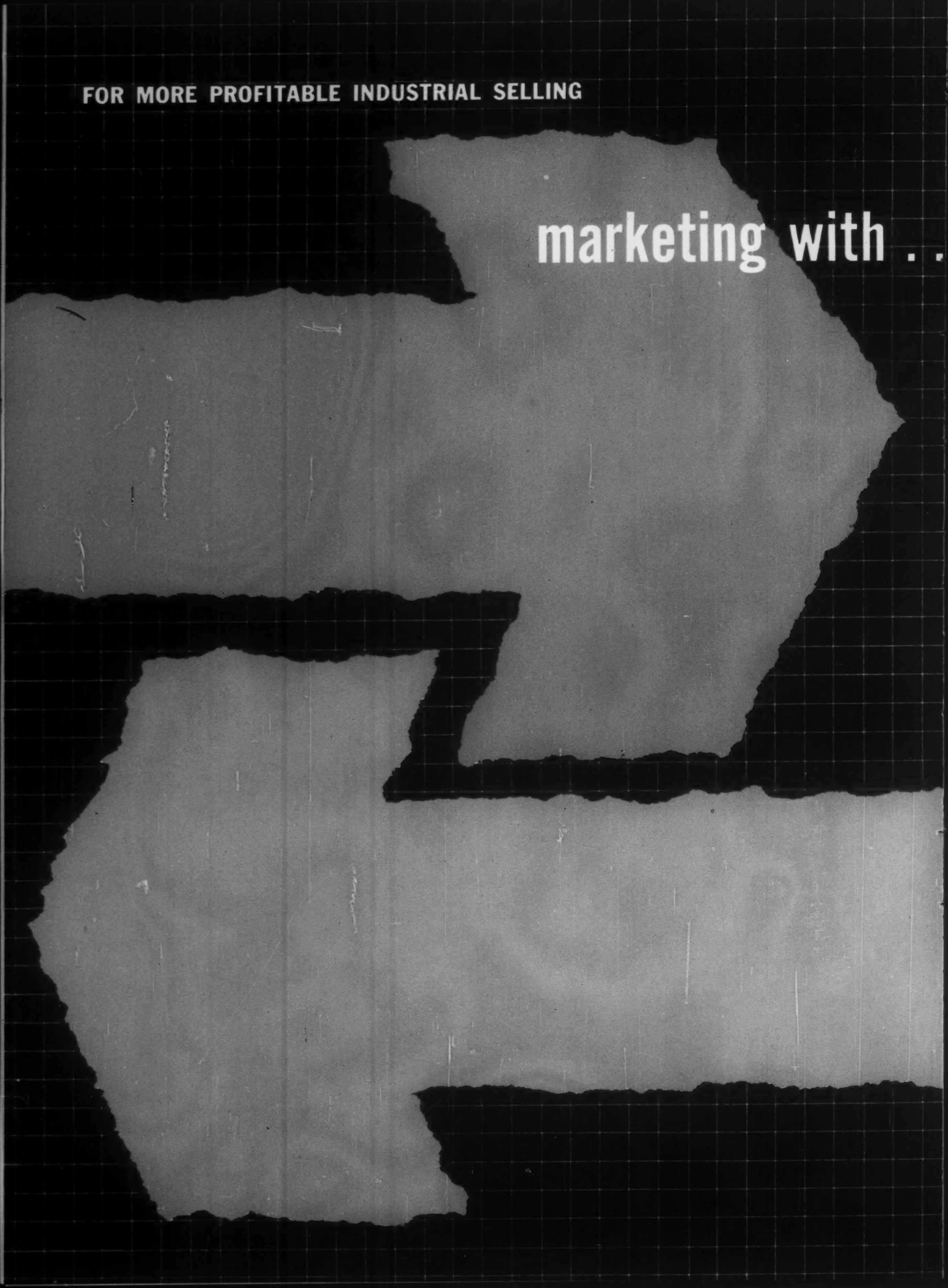
For **reliability** in your rack-panel-chassis connectors...connect with Cannon! Write for Bulletin DP-10 and DP-101 Supplement.

CANNON PLUGS

WHERE RELIABILITY IS THE 5TH DIMENSION

AWARENESS OF PROBLEM
INTEGRITY OF INTENT
DESIGN EFFORT
MANUFACTURING CONTROL

Circle 435 on Page 19


FOR MORE PROFITABLE INDUSTRIAL SELLING
marketing with . .

. . two-way communication

Industrial selling is *tougher.*

But, in the face of this, top management is calling for more sales at a profit.

Better marketing—total marketing—is the answer to moving more goods within industry.

That is why so many industrial companies are bringing research, production, engineering, finance and advertising into the closest coordination with selling. Profit from every sale results when you coordinate capacity to sell and capacity to produce.

This concept of marketing demands a strong program of good communication—*two-way communication.* ⇄

Communication *from* ⬅ your market, to tell you what products are wanted and needed.

Communication *to* ➡ your market, to make the extra contacts you need to help salesmen defeat the problems of group buying patterns and turn more *calls* into *sales.*

Good communication *from* the market depends on your sources of information. You'll find practical, helpful information in MACHINE DESIGN's "Geographical Analysis of the Original Equipment Market"; AUTOMATION's "Confidential File"; FOUNDRY's "Foundry Industry Marketing Guide"; STEEL magazine's new book "Metalworking Markets in the U.S."; N.E.D.'s "How to Get Industrial Buying Action".

Consult your Penton man. He's interested in helping you get the results management wants—more industrial sales at a profit.

the PENTON
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cleveland 13, ohio

AUTOMATION / FOUNDRY / MACHINE DESIGN / NEW EQUIPMENT DIGEST / STEEL

News about

B.F.Goodrich Chemical *raw materials*

Some of the wide variety of rigid vinyl extrusions currently being made by Industrial Vinyls, Inc., Miami, Florida, for many types of applications. B. F. Goodrich Chemical Company supplies the Geon polyvinyl materials.

Extrusions unlimited...in durable Geon rigid vinyl

A PROVEN performer in vinyl piping, Geon rigid vinyl compounds can be produced in a virtually unlimited number of other extruded shapes.

These unplasticized rigid compounds offer high structural and impact strength in addition to the basic advantages of all Geon polyvinyl materials. These include such properties as chemical inertness, resistance to most acids, alkalis, oils, and solvents, durability and abrasion resistance.

Geon 8700A and 8750 rigid compounds are meeting a steadily increasing number of structural and design requirements. Why not consider them in solving *your* particular problem. For booklet listing properties write Dept. LO-4, B.F.Goodrich Chemical Company, 3135 Euclid Ave., Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ont.

A TRADE MARK OF B. F. GOODRICH CHEMICAL COMPANY
Geon
Polyvinyl Materials
A DIVISION OF THE B. F. GOODRICH COMPANY

B.F.Goodrich Chemical Company
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GEON polyvinyl materials • HYCAR American rubber and latex
GOOD-RITE chemicals and plasticizers • HARMON colors

Circle 436 on Page 19

LEVER OPERATED—NO SPRING—$52.00 LIST*

STEM OPERATED—NO SPRING—$50.00 LIST*

CAM OPERATED—SPRING OFFSET—$62.00 LIST*

AIR PILOT OPERATED—NO SPRING—$73.00 LIST*

OIL-PILOT OPERATED—NO SPRING—$42.00 LIST*

PILOT OPERATED, SOLENOID CONTROLLED—NO SPRING—$90.00 LIST*

CHECK the prices! COMPARE the specs!

You'll find this NEW line of valves costs less and operates to higher requirements

. . . and TANDEM SPOOLS are available at no extra cost

Send for complete new Dukes Catalog

DUKES
HYDRAULICS

- Available for pressures up to 3000 PSI
- Choice of 4 spool actions: spring centering, spring offset, no spring in detent or friction pad type
- Choice of 3 standard spools and 5 alternates
- National Acme solenoids
- Full area internal porting
- ½" and ¾" pipe sizes

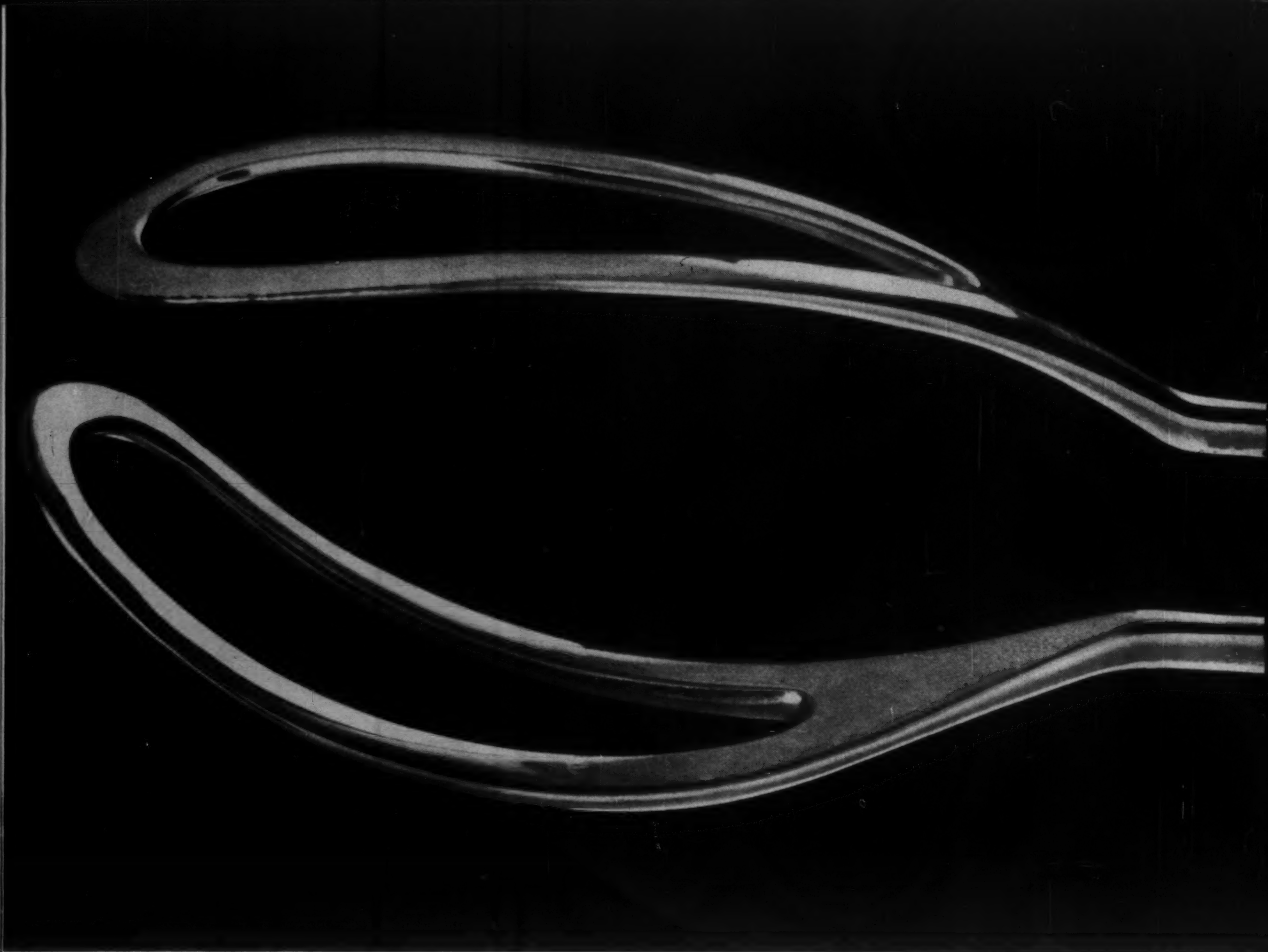
**prices applicable in the U.S.*

DUKES

HYDRAULIC OIL VALVES

Dukes Company Inc. • 3999 North 25th Avenue • Schiller Park, Ill. • A Chicago Suburb

Circle 437 on Page 19



Corrosion Resistance It is an immutable law of Nature that all things seek their most stable state. Nitroglycerine craves opportunity to explode back into passive water and gas vapor. Radium glows silently as it decays into lead. Metals yearn to return to their oxides.

Corrosion is simply the return of a metal to its most stable form. It's an electrochemical process that is generally speeded up by the presence of salts, acids and moisture—in fact, at humidities below 50% there is virtually no atmospheric corrosion of steel. There are six common ways to minimize corrosion: select the right steel, apply protective coatings, install cathodic protection devices, set up periodic cleaning procedures, control the corrosive environment, and use *design* techniques which reduce the cost or likelihood of corrosion.

We have a record of one case where a manufacturer installed expensive piping to transport gaseous chemicals—overlooking the fact that ordinary carbon steel pipe would do the job just as well *if it were insulated* to prevent condensation of the chemicals inside the pipe. Sometimes a vessel is designed with great care so that it will hold a corrosive liquid, only to have the vessel attacked from the *outside* because the support brackets harbored pockets of moisture. And there are cases on record of stress corrosion failure because it was not recognized that stress relieving was necessary after cold working the metal.

Empirical corrosion information can be an excellent guide, but actual service records or true-to-life tests are the safest ways to judge a grade of steel, and you can often avoid the expense and time-consuming nature of making your own tests if you check first with United States Steel. A corrosion problem that is new to you may be familiar to us, and we may be able to supply you with information that will solve your particular problem promptly.

Another good reason for coming to United States Steel is this: no matter what kind of steel you need, you're sure to find it among the vast range of USS Steels for Design. The final selection, of course, should be made by a skilled metallurgist. Our technical staff is always available to consult with you about your problems. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS, COR-TEN, TRI-TEN and "T-1" are registered trademarks

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS United States Steel

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

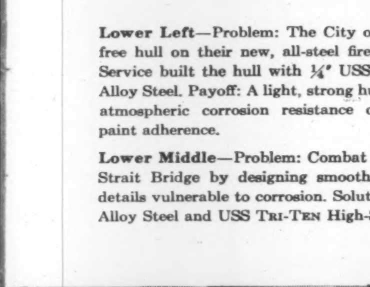
STEELS FOR DESIGN

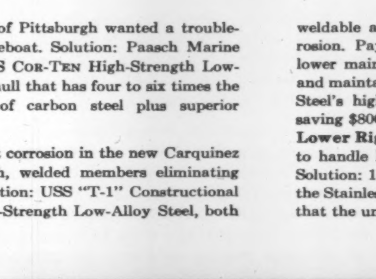
Stainless Steel obstetrical forceps

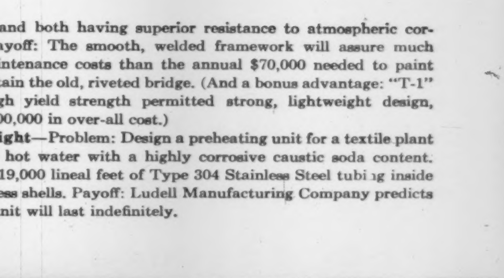
Lower Left—Problem: The City of Pittsburgh wanted a trouble-free hull on their new, all-steel fireboat. Solution: Paasch Marine Service built the hull with ¼″ USS COR-TEN High-Strength Low-Alloy Steel. Payoff: A light, strong hull that has four to six times the atmospheric corrosion resistance of carbon steel plus superior paint adherence.

Lower Middle—Problem: Combat corrosion in the new Carquinez Strait Bridge by designing smooth, welded members eliminating details vulnerable to corrosion. Solution: USS "T-1" Constructional Alloy Steel and USS TRI-TEN High-Strength Low-Alloy Steel, both weldable and both having superior resistance to atmospheric corrosion. Payoff: The smooth, welded framework will assure much lower maintenance costs than the annual $70,000 needed to paint and maintain the old, riveted bridge. (And a bonus advantage: "T-1" Steel's high yield strength permitted strong, lightweight design, saving $800,000 in over-all cost.)

Lower Right—Problem: Design a preheating unit for a textile plant to handle hot water with a highly corrosive caustic soda content. Solution: 19,000 lineal feet of Type 304 Stainless Steel tubing inside the Stainless shells. Payoff: Ludell Manufacturing Company predicts that the unit will last indefinitely.







ALL NEW!

Veeder-Root
Panel-Mounted High Speed
Electrical Counters

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777404
49
01477
0017
66171
000021

...with electric resetting in 1/10th of a second

These new Series 1591 Electrical Counters fill the gap between standard and electronic counters for industrial, data processing, or laboratory and scientific uses. They're designed for accuracy and long life at very high speeds (rated at 3000 counts per minute, with extended test-runs up to 6000 cpm).

And they have the unmatched convenience of *instant push-button resetting*, either mechanically right on the machine . . . or electrically from a distance. Panel-groups of these counters can be placed right in your office . . . *and one button can reset an entire panel*. Counters feature large figures, small size, low-wattage coils for continuous duty and other V-R vantage points on which patents are pending.

These new and different counters are the latest evidence that Veeder-Root design and development always keep pace with modern counting requirements. Write for specifications and prices.

Added Evidence
that Everyone
Can Count on

VEEDER-ROOT
INCORPORATED
HARTFORD 2, CONNECTICUT
Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago
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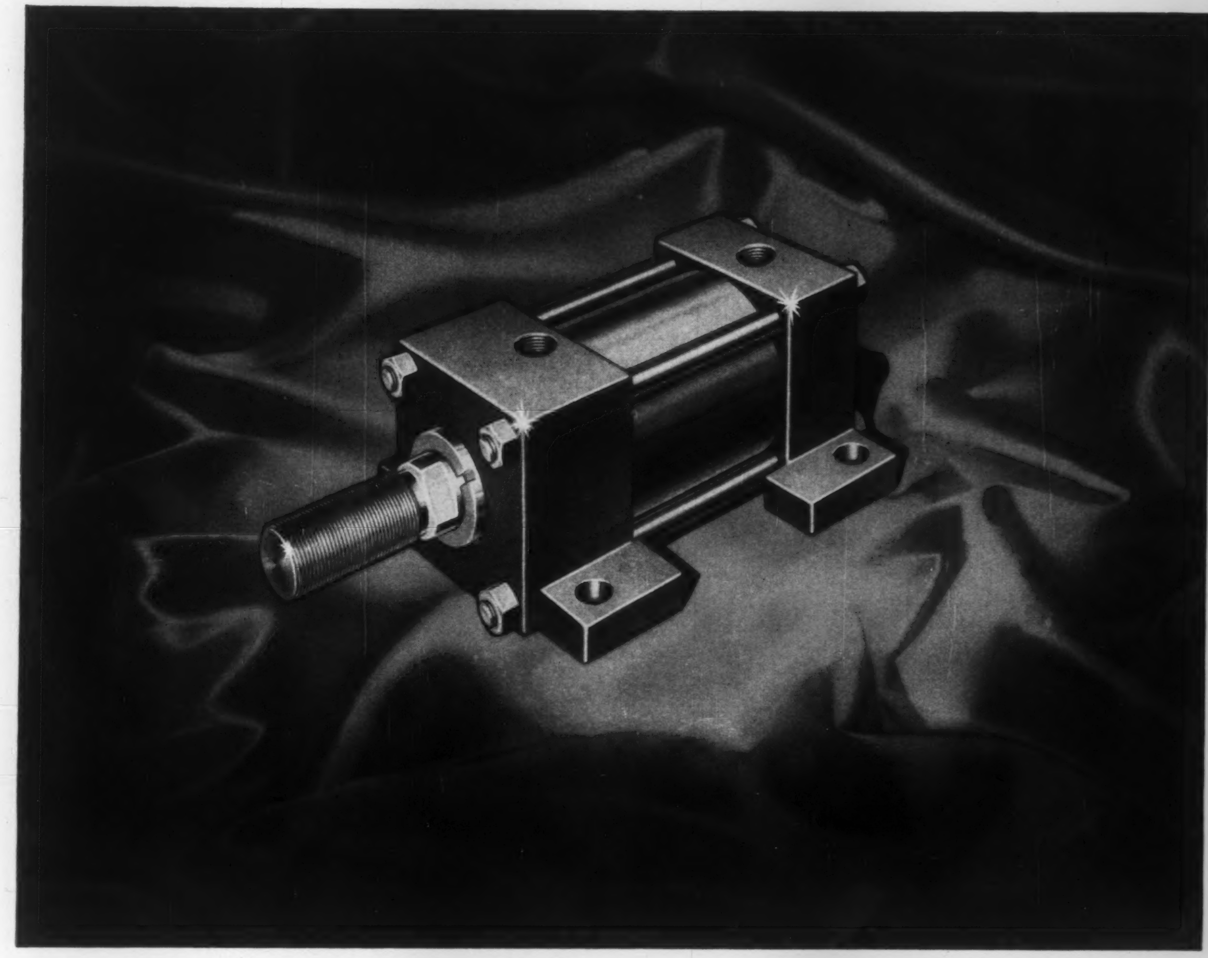
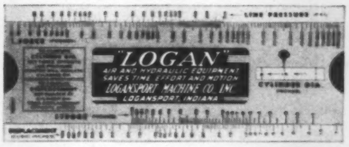
Offices and Agents in Principal Cities



Illustrated—Logan Super-Matic Cylinder
Meets J.I.C. Standards

Look to Logan

the ultimate in hydraulic cylinder design


"LOGAN"
AIR AND HYDRAULIC EQUIPMENT
SAVES TIME EFFORT AND MOTION
LOGANSPORT MACHINE CO. INC.
LOGANSPORT, INDIANA

FREE SEND FOR THE "LOGAN CALCULATOR"

MEMBER: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

LOGANSPORT MACHINE CO., INC.
811 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-6 ULTRAMATION CYLINDERS
- ☐ 300-2 PRESSES
- ☐ FACTS OF LIFE
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 AND 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 300-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

TO:

NAME ______________________ TITLE ____________

COMPANY ______________________

ADDRESS ______________________

Circle 439 on Page 19

BR
15
Plug buttons by
F
LR
Prongs snap into punched or drilled hole
DOT
RR
0

CUSTOM-DESIGNED AND MASS PRODUCED TO YOUR PARTICULAR REQUIREMENTS

Dot plug buttons were originally used in automobiles to fill spaces on standard models which, on de luxe models would be occupied by such extras as cigarette lighters, radio controls and so on. They are now also widely used as lenses for indicator lights and as identification buttons on instrument and control panels of all kinds.

Available in clear or colored plastics... brass or steel in all standard finishes... embossed and enamel-filled or molded to show company insignia or other identification symbols . . . Dot plug buttons snap into place and stay where they're put even under conditions of extreme vibration. Yet they can be removed and replaced repeatedly without damage.

CARR FASTENER COMPANY

DIVISION OF UNITED-CARR FASTENER CORPORATION 31 Ames Street, Cambridge 42, Massachusetts

MAKERS OF **DOT** *FASTENERS*

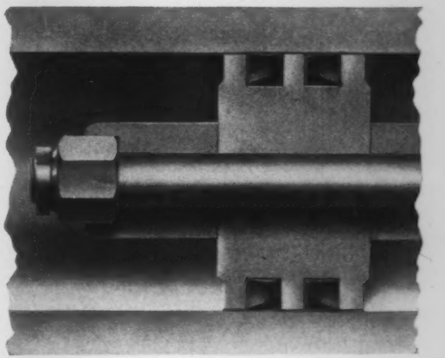
Circle 440 on Page 19

ONE OF THE GARLOCK 2,000

NEW FLARED-LIP U-CUP PACKING REDUCES FRICTION

Garlock's new homogeneous U-cups are designed for minimum frictional resistance in low pressure air or hydraulic cylinder applications. They are molded of synthetic rubber with flared sidewalls which also facilitate assembly, especially when cylinder bores vary slightly in size. Instantaneous sealing after sudden pressure changes is another advantage of the flared-lip design. Sizes ½″ O.D. to 3¾″ O.D. are available from stock. Sizes to meet all AN6226 and JIC dimensional specifications.

Homogeneous U-cups are another part of the famous "Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals to meet all your needs. It's the only complete line . . . it's another reason you get unbiased recommendations from your Garlock representative. Call him or write for AD 163.



The new Garlock 9511 U-cup Packing is recommended for pressures to 2000 psi. The flared-lip design creates an interference fit especially adaptable to applications involving sudden pressure changes. Clearance at the heel reduces friction, makes assembly easier.

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.
For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Plastic Products, Molded and Extruded Rubber

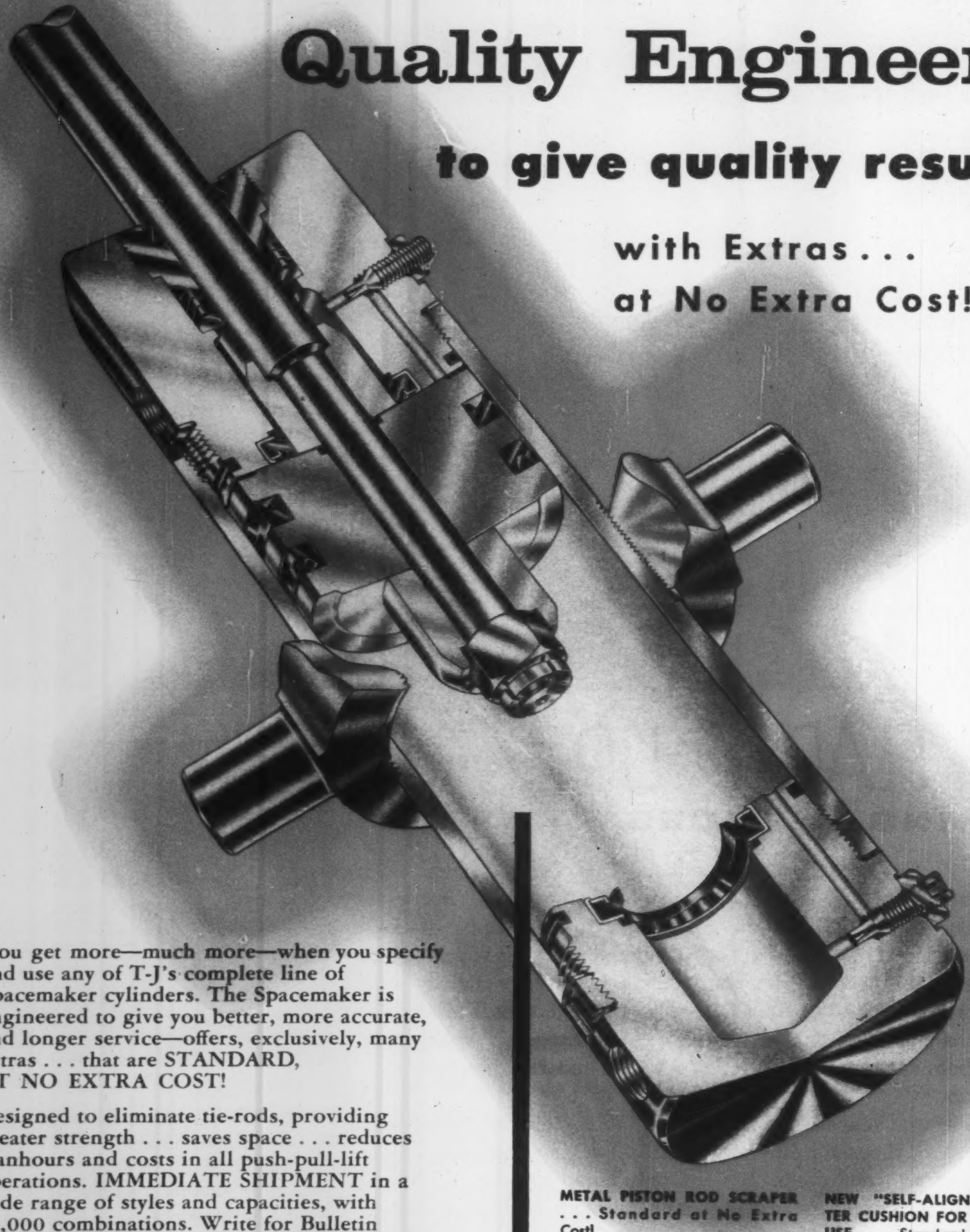
Circle 441 on Page 19

T-J spacemaker cylinder

Quality Engineered

to give quality results

with Extras . . . at No Extra Cost!



You get more—much more—when you specify and use any of T-J's complete line of Spacemaker cylinders. The Spacemaker is engineered to give you better, more accurate, and longer service—offers, exclusively, many extras . . . that are STANDARD, AT NO EXTRA COST!

Designed to eliminate tie-rods, providing greater strength . . . saves space . . . reduces manhours and costs in all push-pull-lift operations. IMMEDIATE SHIPMENT in a wide range of styles and capacities, with 64,000 combinations. Write for Bulletin SM 155-3 with complete engineering details. The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON
RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

METAL PISTON ROD SCRAPER . . . Standard at No Extra Cost!

NEW "SUPER" CUSHION FOR AIR . . . Standard at No Extra Cost!

CHROME PLATED CYLINDER BORES AND PISTON RODS . . . Standard at No Extra Cost!

ONE PIECE PISTON . . . Standard at No Extra Cost!

NEW "SELF-ALIGNING" MASTER CUSHION FOR HYDRAULIC USE . . . Standard at No Extra Cost!

NO TIE-RODS TO STRETCH . . . Standard at No Extra Cost!

STREAMLINED DESIGN . . . Oil Pressure to 750 P.S.I.—air to 200 P.S.I. Standard at No Extra Cost!

FORGED SOLID STEEL HEADS . . . Standard at No Extra Cost!

Circle 442 on Page 19

News about HYPALON®

Seals of HYPALON in heat exchanger are undamaged by 125° F. aqua regia fumes

J. Bishop & Co. Platinum Works, refiners of precious metals at Malvern, Pa., have installed a new shell-and-tube heat exchanger to condense aqua regia fumes for safe disposal. The exchanger contains 1,275 Pyrex tubes each ⅜ in. diameter and 10 ft. long. Water circulates through the tubes; the aqua regia fumes are on the shell side.

Nearly 4,000 plugs of HYPALON, resembling one-hole bottle stoppers, are used to seal the tubes in the tube sheets—one seal per tube at the top tube sheet, two at the bottom. The seals of HYPALON permit thermal expansion and contraction; they prevent intermingling of fumes and water and they withstand aqua regia fumes at 125° F. The seals of HYPALON have been used for over 13 months without a failure.

HYPALON is especially suited for service where conditions are extreme. In addition to chemical resistance, this newest Du Pont synthetic rubber is completely resistant to ozone and highly resistant to heat, abrasion, weathering and flex cracking. Seals, gaskets, tank linings are but a few applications. Send coupon for details.

Seals of HYPALON resist corrosive action of hot aqua regia. 3,825 seals are used in this heat exchanger.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

Neoprene shock absorbers replace flywheel in flyweight generator

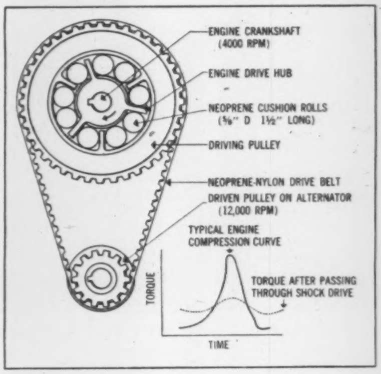
Neoprene was chosen by Lear, Inc., of Santa Monica, Calif., in the design of a portable 1500 watt engine-generator set that weighs only 35 lbs. It consists of a 1200 rpm permanent-magnet generator driven by a toothed belt from a 400 rpm one-cylinder two-cycle engine.

There is no flywheel. It was eliminated to save weight. Instead, Lear engineers have interposed nine cylindrical neoprene cushions in the power train between the engine crankshaft and the drive pulley (see drawing). The cushions iron out torque surges inherent in a one-cylinder engine.

Engine pulsations rapidly wore out drive belts in an early experimental model built without flywheel or cushions. Now, models with neoprene shock absorbers get good service life from drive belts. (Belts are neoprene reinforced with nylon, toothed to maintain a strict 3-to-1 ratio between generator and engine.)

Neoprene was chosen for both the belt and cushions because it is the only rubber that resists both oil and ozone at once. In addition, neoprene's resistance to heat, abrasion, chemicals, grease and weather gives you an outstanding combination of properties for designs that call for a durable resilient material. Please mail coupon for more information.

Use of neoprene cushions instead of heavy flywheel cuts weight of this portable 1500 watt generator to 35 lbs.


ENGINE CRANKSHAFT (4000 RPM)
ENGINE DRIVE HUB
NEOPRENE CUSHION ROLLS (⅝" D 1½" LONG)
DRIVING PULLEY
NEOPRENE-NYLON DRIVE BELT
DRIVEN PULLEY ON ALTERNATOR (12,000 RPM)
TYPICAL ENGINE COMPRESSION CURVE
TORQUE AFTER PASSING THROUGH SHOCK DRIVE
TORQUE
TIME

ELASTOMERS IN ACTION HYPALON® • NEOPRENE

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living
. . . through Chemistry

☐ I am particularly interested in ____________

☐ Send me a free copy of *The Du Pont Elastomers* (a review of properties of neoprene and HYPALON).

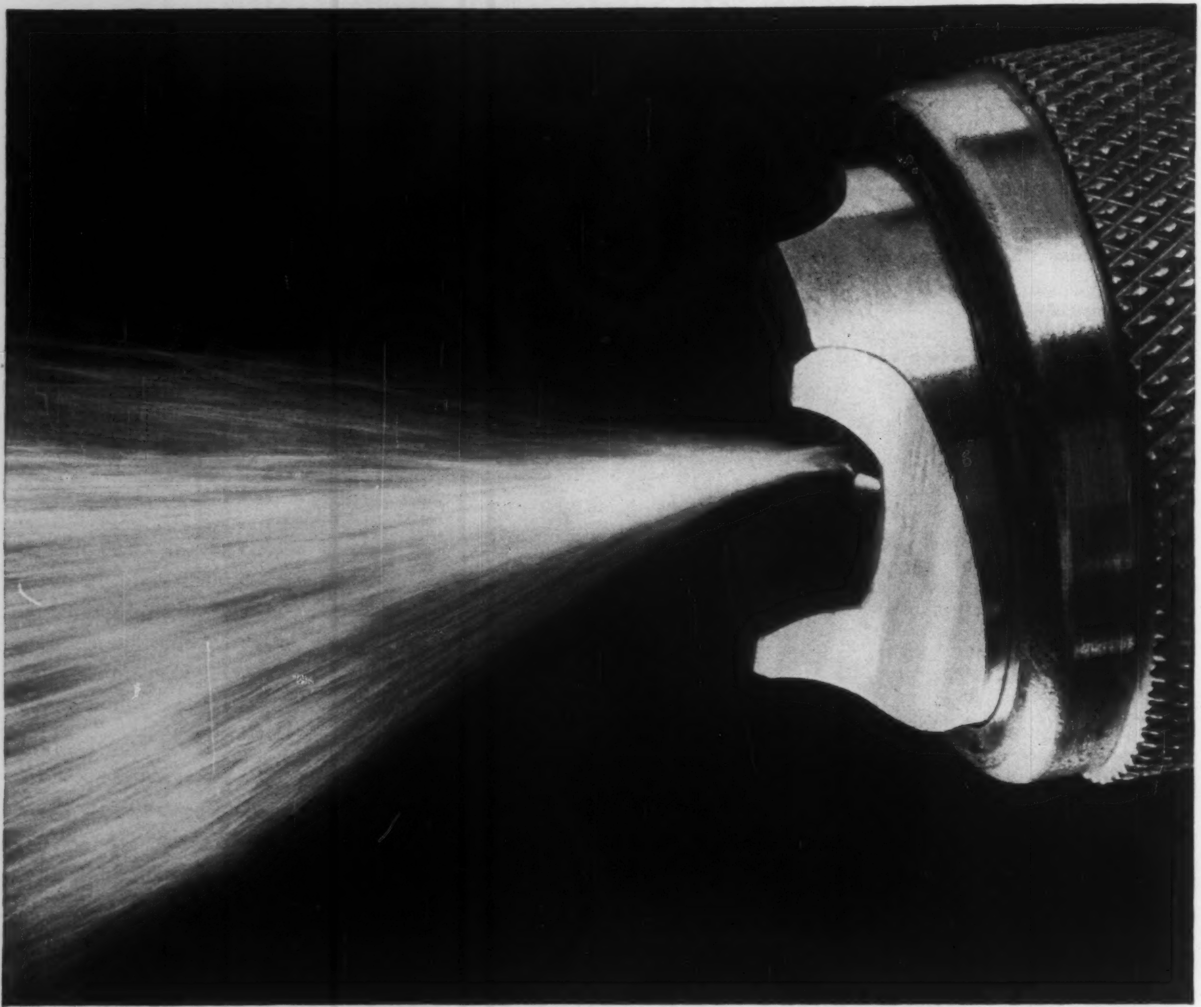
☐ Add my name to the free mailing list of the *Elastomers Notebook* (contains articles based on uses of Du Pont elastomers in industry).

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. MD-7
Wilmington 98, Delaware

Name ____________
Firm ____________
Address ____________
City ____________ State ______

Circle 443 on Page 19

EC-1357 by 3M Sprays on Smoothly for Stronger Sandwich Bonds!



3M ADHESIVE EC-1357 MINIMIZES COBWEBBING IN SPRAY APPLICATIONS FOR BETTER SURFACE-WETTING, FAR BETTER ADHESION.

Solvent blending makes the big difference! Exact amounts of several solvents are skillfully mixed to achieve the precise blend required for a superior sandwich-bonding adhesive. The result: spray application is easier, greatly reduced cobwebbing saves materials, better surface-wetting provides far better skin-to-core adhesion.

With EC-1357, sandwich structures can be bonded on a cold press or nip roller to provide high ultimate strength. For use with or without force-drying, EC-1357 can be adapted to the widest variation in production-line techniques and speeds. Good to excellent immediate bonding strengths are achieved, depending on the drying method used. Because it is dark-colored, EC-1357 absorbs infrared heat fast. For a similar, light-colored adhesive, investigate EC-1368.

The high moisture- and weather-resistance of EC-1357 and EC-1368, plus their capacity to hold fast through a wide temperature range, make them ideal in unusually severe climates.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU! For technical assistance, contact any one of our 19 branch offices located in principal cities throughout the United States. Six plants provide local service for faster delivery. For free literature, write on your company letterhead to: 3M, Dept. C-7, 417 Piquette Ave., Detroit 2, Michigan.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

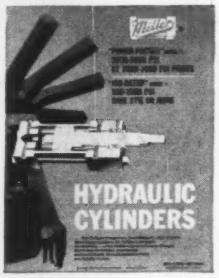
SEAL FAILURE MEANS CYLINDER FAILURE

Petroleum base, fire-resistant and special hydraulic fluids cause distortion and rapid deterioration of the seals currently used in many hydraulic cylinders, resulting in costly repairs and cylinder failure. (Seals made of synthetic rubber are not compatible with even 50% of available commercial petroleum base fluids and the life of such seals is materially reduced at operating temperatures above 150° F.)

Specify Miller HYDRAULIC CYLINDERS

FOR UNLIMITED SEAL LIFE!

Request Bulletin JH-104N for complete data plus helpful charts on column strength, cylinder forces, factors of safety, acceleration, pipe pressure losses, etc.



1

ALL TEFLON* SEALED Against External Leakage

TEFLON is impervious to all known hydraulic fluids, including all fire-resistant and special types — and withstands temperatures from —100°F. to plus 450°F.

TEFLON SHEF SEAL AT TUBING ENDS

No blind assembly. Is

Shear-proof
Heat-proof
Extrusion-proof
Fluid-proof

TEFLON SEALS ON PISTON ROD AND BUSHING

Teflon rod flange seal requires no adjustment. Teflon bushing seal is shearproof. Teflon wiper keeps dirt out.

TEFLON SEALS ON BALL CHECK AND ADJUSTING SCREW

Non-protruding, self-locking, cushion adjusting screw interchangeable with ball check for easy access.

2

CASE-HARDENED CHROME PLATED PISTON RODS

Provide foolproof protection against seal failures resulting from rod damage. The Miller case-hardened rods (50-54 Rockwell C) give practically complete immunity to damage from hammer blows, wrench-dropping, mishandling, etc. The hard chrome plating over the case-hardened rods protects against scratch-damage and rust.

AVAILABLE IN TWO TOP QUALITY LINES

JOB-RATED
Model "J"

PRICE SAVINGS OF 27% OR MORE!

19 mounting styles, all strokes, cushioned and non-cushioned. Large selection for immediate shipment.

BORE	SEVERE OPERATING CONDITIONS	MODERATE OPERATING CONDITIONS	YOU SAVE THIS % IN PRICE OVER STANDARD 2000-3000 PSI CYLINDERS
1½"	1500 PSI	2500 PSI	27%
2	1500	2500	27%
2½	1000	1500	28%
3¼	1500	2500	32%
4	1000	1500	35%
5	800	1200	37%
6	800	1200	43%
8	500	800	50%
10	500	800	71%
12	500	800	76%
14	500	800	*Not Available in 2000-3000 PSI*

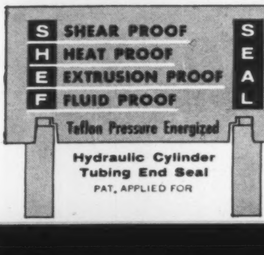
POWER-PACKED
Model "H"

50% More Power Per Cylinder Dollar!

For
3,000-5,000 P.S.I.

1½" through 12" bores, 17 mounting styles, strokes up to 22 ft., cushioned and non-cushioned. Large selection for immediate delivery.

*DuPont trademark for its tetrafluoroethyline resin



Hydraulic Cylinder Tubing End Seal
PAT. APPLIED FOR

OTHER MILLER QUALITY FEATURES

- Solid Steel Heads, Caps and Mountings.
- Precision-Honed Barrels.
- Rust-Resistant Coating on All Non-Wearing Surfaces.
- Space-Saving "Square" Design.

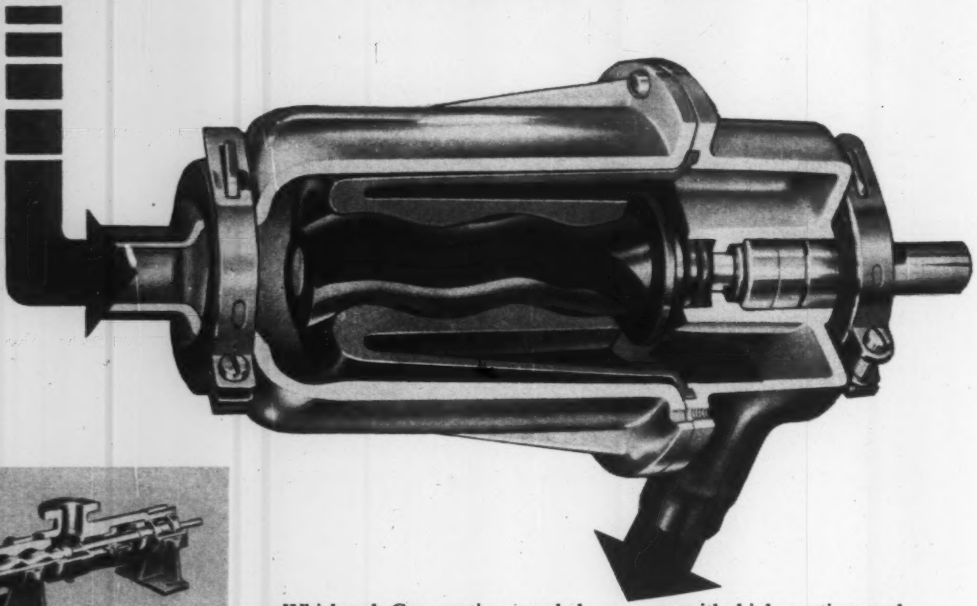
MILLER FLUID POWER
DIVISION OF FLICK-REEDY CORPORATION

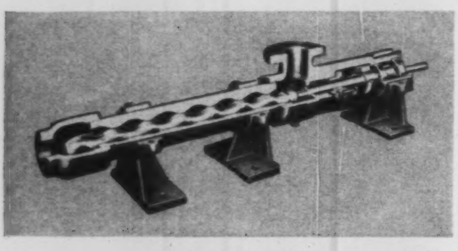
2006 N. Hawthorne Ave. Melrose Park, Ill.

AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

Circle 445 on Page 19

MOYNO® Pumps Oceans (Pebbles and all) for RCA WHIRLPOOL Washer-Dryer





Industrial type Moyno . . . available to 500 gpm, pressures to 1000 psi.

Whirlpool Corporation needed a pump with high suction and positive displacement for its automatic combination Washer-Dryer. Though sparing of water during wash-and-7-rinse cycle, each RCA Whirlpool combination circulates oceans during its long life. A Moyno Pump provides the continuous, uniform flow, 1 to 15 gal./min., free from air locking. Most important, even relatively large particles—sand, pebbles, children's pocket loot—can't stop a Moyno Pump!

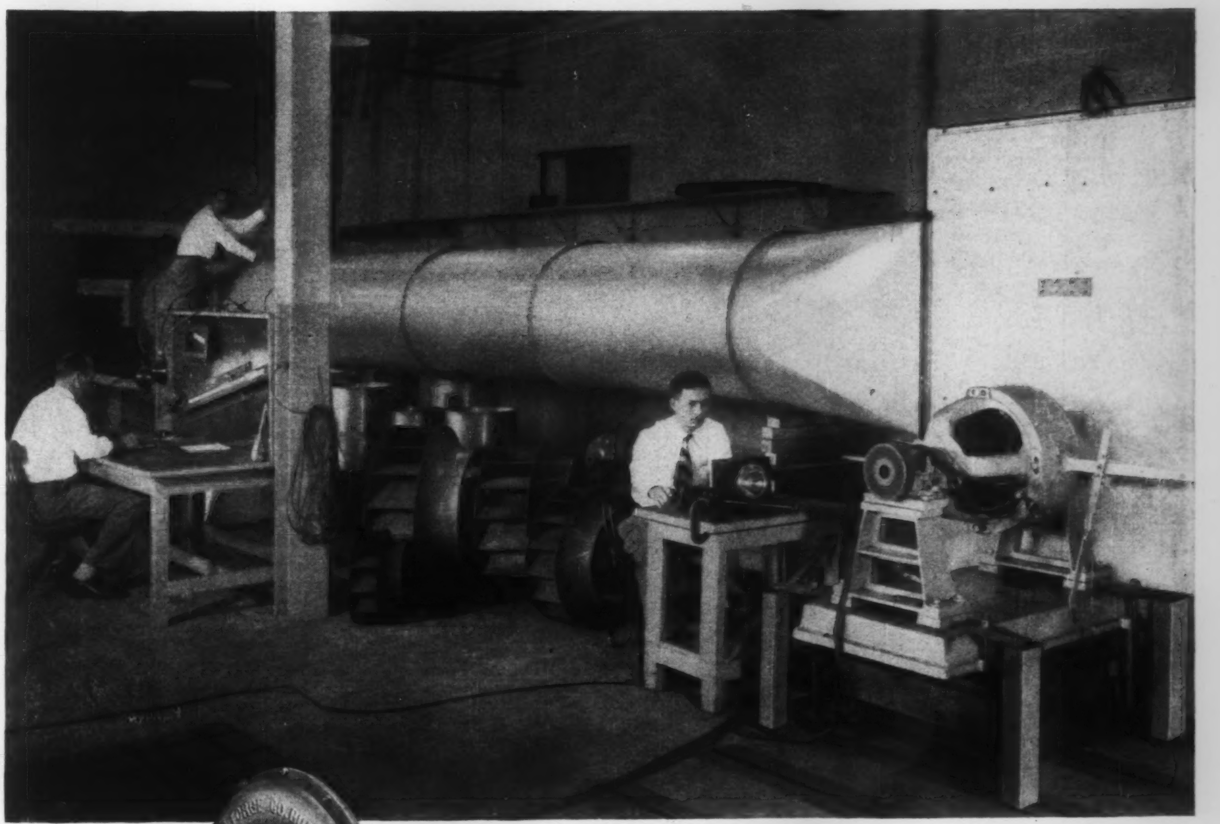
In fact, Moyno's revolutionary, yet simple design can pump anything that can be forced through a pipe! A helical screw-like rotor turning inside a double-helical stator forms progressing cavities that don't squeeze . . . can't stick or gum up . . . will not cause churning, foaming . . . won't aerate or vapor-lock. On OEM products and in pilot plants, small Moynos solve pumping problems that are different, difficult or downright destructive to ordinary pumps. Write today for Bulletin—50 MD!

ROBBINS & MYERS, INC.

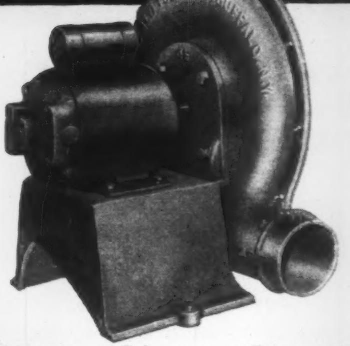
SPRINGFIELD, OHIO
BRANTFORD, ONTARIO

MOTORS · FANS · HOISTS · MOYNO® PUMPS · (INDUSTRIAL) PROPELLAIR® FANS

Circle 446 on Page 19

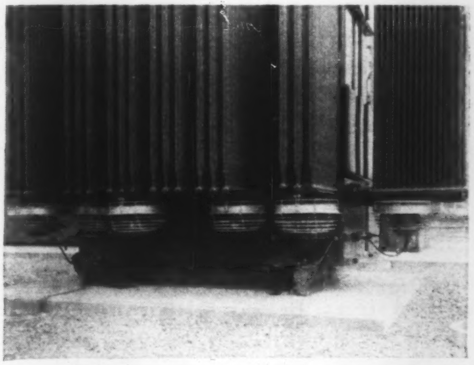


THE "BUFFALO" FAN YOU BUY HAS PROVEN ITS ABILITY!



"Buffalo" Blowers and Exhausters — efficient small units for a variety of uses. Bulletin FM-900.

Special design propeller fan — custom built for specific installation.



When you select a "Buffalo" fan as a part of your product, you are assured of rated performance.

If you specify a standard unit, you know the design has been tested and rated, and tables are available for you to select the exact air movement required.

If you have special conditions to be met, "Buffalo" will design and test the fan for performance. Here is what one customer had to say: "Our engineers express appreciation for the very fine job you did — predictions for air delivery and noise levels were highly accurate."

The next time you want an air handling unit of proven performance, call your nearest "Buffalo" Engineering representative. Or write direct to the factory for recommendations on your particular requirements.

BUFFALO FORGE COMPANY
Buffalo, New York
Buffalo Pumps Division, Buffalo, N. Y.
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo"

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Circle 447 on Page 19

Photo taken at Continental Can Company's Chicago Laboratory

Republic's fabricating "Know How" helps Continental Can Company

BEAT THE HEAT AND COLD!

In a specially constructed "torture" chamber, the Continental Can Company, Chicago, exposes thousands of cans and their contents to extreme heat and cold.

The customer wanted rack-type shelving with sliding shelves that could be quickly and easily adjusted to accommodate a variety of can sizes and types, yet still weather the severe changes in temperature. Republic's Berger Division took over the problem, came up with the solution. Through its contract manufacturing facilities and equipment, Berger took the whole job off the customer's hands.

In Berger Plants many sheet steel products are fabricated for other customers and marketed under the manufacturer's brand name.

Berger's large stocks of standard tools, dies, and specialized equipment for punching, shearing, forming, welding, and Bonderizing are available to you. Constant research and development at Berger have resulted in advanced processes and equipment to make your fabricated sheet steel products more attractive, and more economical.

Men of Berger's national sales force will help work with you to solve sheet steel product problems . . . whatever your location. With Berger manufacturing, you get the sales advantage of shipment out of well-located Canton, Ohio. Republic's fabricating "know-how" provides you with the same high quality you see in Berger Division products—lockers, office furniture, shelving, and steel kitchens.

Send a sketch or blueprint with complete specifications. Berger will tell you promptly what their specialized services can do for you. Detailed information is available in Bulletin 1090.

▲ **SOLVE THE PROBLEM** of storing heavy items with Republic Wedge-Lock Steel Shelving. It is specifically designed for high stacking of enormous weights. The joints actually get tighter as more weight is added. Wedge-Lock Steel Shelving provides maximum loading in minimum floor space. Shelves can be easily adjusted — whole units can be converted or combined to suit changing needs. It can be easily and quickly assembled. Send coupon for full information.

REPUBLIC FILING CABINETS are available in a wide range of styles and sizes to meet any office filing requirement. Drawers coast on cradle-type progressive ball-bearing suspension slides. All steel construction withstands exceptionally hard use. See your dealer—or send coupon today.

REPUBLIC STEEL LOCKERS are Bonderized to preserve their fine finish and protect against rust. They combine smart styling and design with simple construction, for fast, easy installation. They provide full inside locker roominess, sanitation, and safety. Send coupon for literature.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
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1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

☐ Send Bulletin 1090 describing Berger Fabrication facilities and abilities

Please send more information on:
☐ Wedge-Lock Steel Shelving ☐ Lockers ☐ Filing Cabinets

Name__________ Title__________
Firm__________
Address__________
City__________ Zone____ State______

Circle 448 on Page 19

Need a Fastener that Hasn't Been Invented?

Chances are you'll pay top price for it. But by following these six rules you can avoid the high cost of becoming an inventor!*

IT'S natural to assume that, after designing a piece of equipment, you'll have no trouble finding standard fasteners to fit it. Usually such fasteners will be readily available. But what happens when you find yourself with a finished design that doesn't lend itself to any known fastening method?

The most expensive thing you can do at this point is to start inventing fasteners. Valuable man hours go into research, design, prototypes and testing. And unless you can make these fasteners in very large quantities the unit cost will be high, particularly if tooling is necessary.

Now, here are six tips that can get you out of trouble—and keep you out:

1. Remember—not all standard specialty fasteners are listed in fastener manufacturers' catalogs. The fastener company that serves you is probably tooled up for hundreds of non-standard devices, designed and produced to solve problems like yours for other customers. Maybe one would meet your requirements. You'd save the development and tooling charges.

2. There may be a stock fastener available for this job that hasn't come to your attention. Discuss the problem with the fastener manufacturer. If he has nothing in stock, he may be able to modify one of his standard devices at very nominal extra cost.

3. Don't overlook free professional help! Your fastener manufacturer will be glad to offer advice and design service—he does it for everyone else. Unload the problem on him, and let his experience work for you.

But you'll save money if you avoid specifying the fastener that hasn't been invented. By following the next three rules you can usually keep from reaching the point where a non-standard device might be necessary.

4. Go into the fastening problem during the early stages of design. Design your closures with standard fastenings in mind. You won't be left with the costly choice of inventing a fastener or redesigning your product.

5. Keep a complete file of fastener manufacturers' catalogs. Your product designers seldom are fastener specialists too, but they can have complete information available when they need it—at the design level.

6. Work closely with the Fastener Sales Engineer who calls on you. He's trained and paid to help solve your problems. Take full advantage of this service.

Whether you need a standard specialty fastener or the one that hasn't been invented, Southco is well qualified to invite your inquiries. There's no obligation on your part. It's part of our business to offer free consultation at the design or production levels, on items of your own product line, or on those involving military specifications.

Send today for our forty-four page Fastener Handbook No. 8, just printed. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

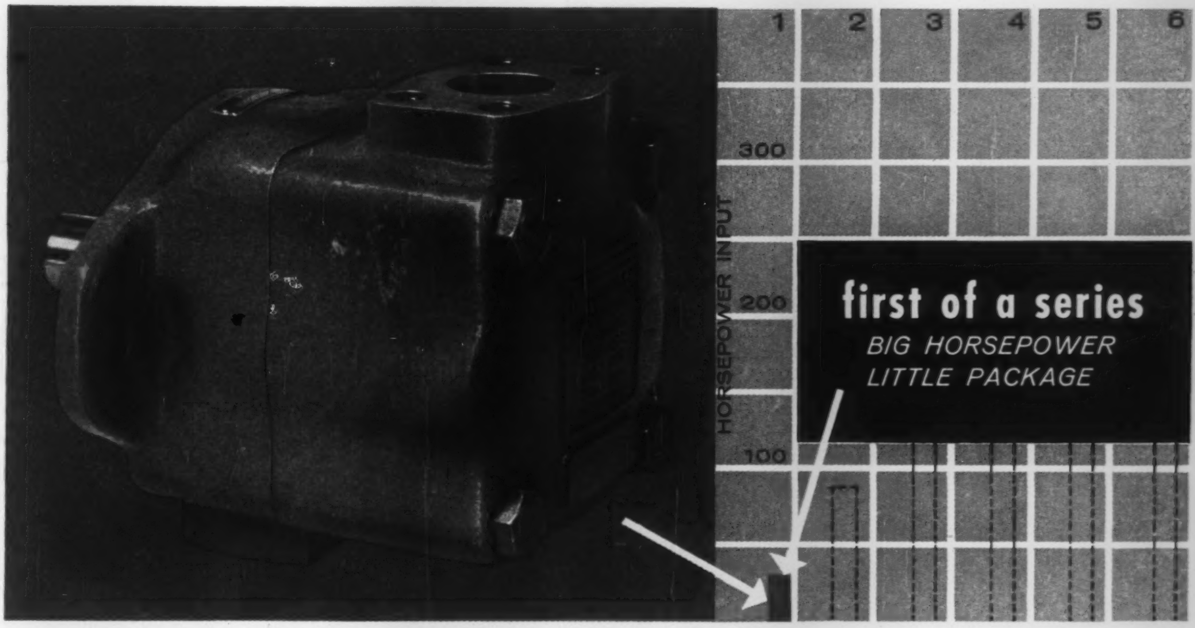
**** Reprints of this page are available on request.***

SOUTHCO

FASTENERS

© 1958

Circle 449 on Page 19



NEW VICKERS® high performance vane pump

• high speed • high pressure • high efficiency • high service life

NEW COMPACT DESIGN . . . more than twice the horsepower of previous pumps in the same package size.

NEW VANE CONSTRUCTION . . . positive vane tracking at all speeds assures efficient operation at increased speeds and pressures.

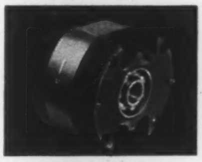
NEW SIZES not previously available . . . answers mobile equipment designers' need for greater hydraulic horsepower in limited space.

NEW PARTS INTERCHANGEABILITY . . . many common parts for single and double pumps (two pumps on the same shaft in one envelope). Lessens inventory requirements.

NEW 4-BOLT SAE FLANGE CONNECTIONS . . . will also accommodate user's 2-bolt flanges of the proper design.

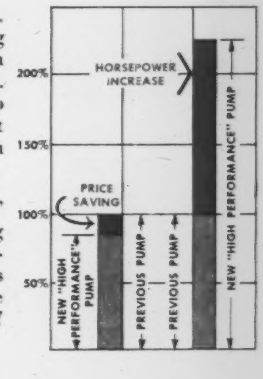
NEW 2-BOLT MOUNTING (SAE 1959 STD.).

NEW REPLACEABLE PUMPING CARTRIDGE . . . all wearing parts of pump are incorporated in one replaceable cartridge. Easy field replacement without removing pump from its mount. Cartridges available in kit form.



MORE HORSEPOWER PER DOLLAR. The graph at the right makes a revealing comparison between this new pump and a previous pump of the same rated delivery. The new Vickers "High Performance" pump provides more than *twice the horsepower* at *less cost* while shrinking package size from 200 to 112 cubic inches.

The complete line of "High Performance" pumps (both single and double) is being readied for release. Size range will accommodate your largest requirements. This first model of the series is available in three ring capacities; 12 gpm, 14 gpm, and 17 gpm as shown in table below.



Model Number	Delivery-GPM		Input Horsepower @ 2000 RPM 2000 PSI	Package Size†	Weight
	1200 RPM 100 PSI	2000 RPM 2000 PSI			
2V12A-**10	11.8	17.8	25.5	L. 5⅜" W. 4⅝" H. 5¾"	26 Lb.
2V14A-**10	13.6	20.4	29.0		
2V17A-**10	16.6	25.2	36.0		

†Exclusive of Shaft Extension and Mounting Lobes

8050

Write for new illustrated Bulletin No. M5108 for further details and performance characteristics.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Mobile Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

Application Engineering Offices: • ATLANTA • CHICAGO • CINCINNATI CLEVELAND • DETROIT • GRAND RAPIDS • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Springfield, N.J.) PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) PORTLAND, ORE. • ROCHESTER • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS • TULSA
FACTORIES ALSO IN AUSTRALIA, ENGLAND, GERMANY AND JAPAN
IN CANADA· Vickers-Sperry of Canada, Ltd., Toronto, Montreal and Vancouver

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Engineered by Tinnerman . . .

3-way savings for Chrysler Corporation when one **SPEED NUT**® replaced 5 parts

Four parts eliminated . . .

Parts cost reduced 40% . . .

Assembly costs cut 12% . . .

All these savings were accomplished when the Chrysler Corporation switched to a Tinnerman-engineered SPEED NUT Brand Fastener developed to hold car and truck window vents in place. The all-spring-steel fastener serves as a friction brake to hold the vent at any desired position.

You, too, can achieve savings like these on parts for your assemblies . . . a no-obligation Tinnerman SPEED NUT Fastening Analysis will quickly locate the places. Your Tinnerman sales representative will discuss your problem, arrange for the Analysis. He's listed in your Yellow Pages under "Fasteners." Or write to:

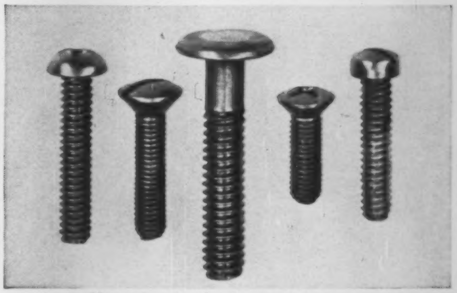
TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®
FASTEST THING IN FASTENINGS®

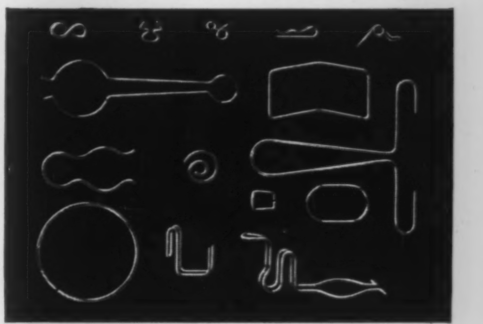
CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

Quality products start with J&L stainless steel wire

Long-lasting filters and screens are woven from stainless steel wire.



Many types of screws are more economically formed by cold heading.



Various shapes made with J & L slide forming wire.

Many types of products are fabricated from stainless steel wire. We suggest you consider Jones & Laughlin Stainless Steel Wire where ease of forming or special corrosion or heat resisting properties are required.

For *your* particular application or production problem, we offer the services of our stainless steel specialists. A letter or call will receive prompt attention.

stainless
steel wire
manual
J&L STAINLESS

Wire today for your copy of J & L's new Stainless Steel Wire Manual.

Improve your Products with . . .

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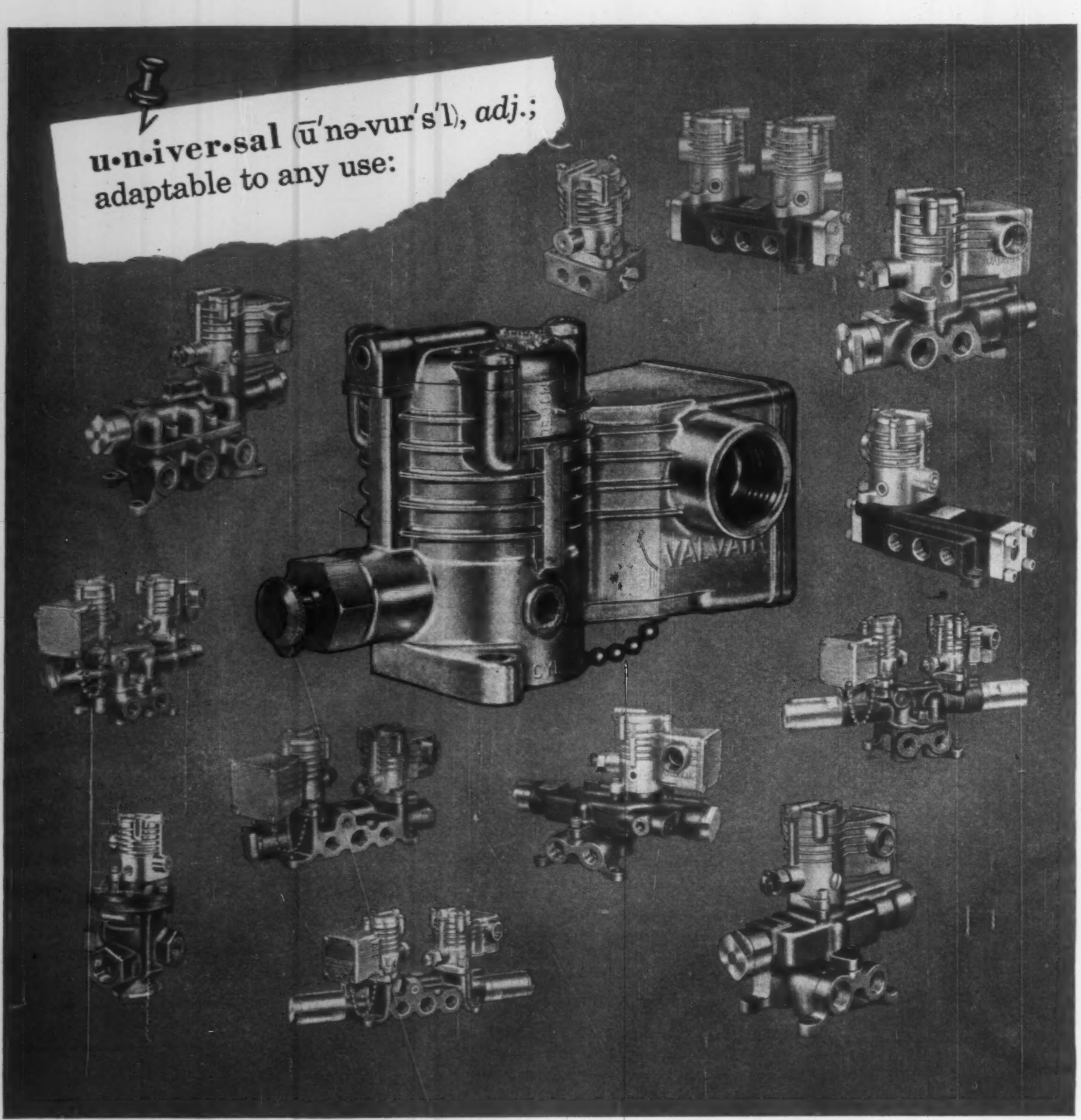
BAR • WIRE • SHEET • STRIP

Jones & Laughlin Steel Corporation • STAINLESS STEEL DIVISION • Box 4606, Detroit 34

Circle 452 on Page 19

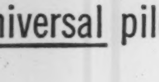


VALVAIR'S universal pilot operates any SPEED KING valve!

Find us fast in the "Yellow Pages"

Compare . . . and you'll buy

Valvair



Immediate delivery from local stock

Valvair's one *universal* pilot—completely interchangeable on all Speed King valves—has only two moving parts. It's built to handle your toughest jobs.

Why complicate production, maintenance and parts inventory on the machines you build or operate, by using control valves that require an assortment of pilots?

For peak performance . . . unmatched reliability . . . minimum parts inventory . . . specify Valvair Speed Kings, the valves with *universal* pilots! Valvair Corporation, 454 Morgan Avenue, Akron 11, Ohio.

AA-7245

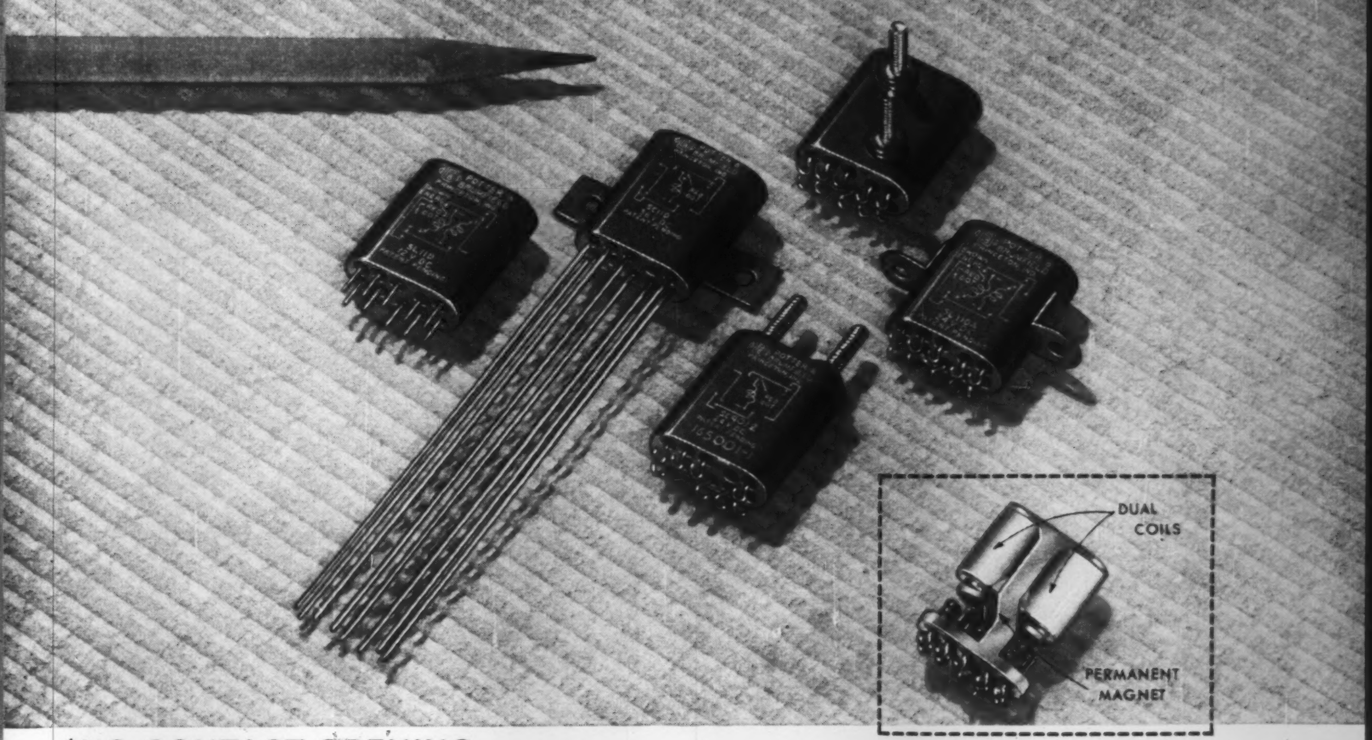
Representatives in principal cities

Circle 453 on Page 19

P&B MICRO-MINIATURE RELAYS LEAD IN

performance

SHOCK: 100g* VIBRATION: 30g to 2000 cps*

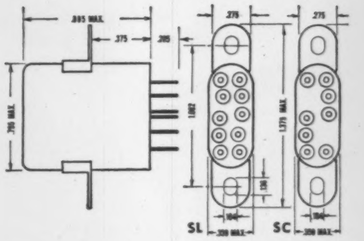


***NO CONTACT OPENING**

New P&B crystal-case size relays, the SC and the SL (magnetic latching), show amazing shock and vibration capabilities. They absorb shocks of 100g and vibrations 30g to 2000 cps. without contact openings!

A highly efficient magnetic structure utilizing a permanent magnet makes possible at least twice the contact pressure found in DPDT relays of comparable size. One watt of power for three milliseconds operates either relay. Transfer time is unusually fast —0.5 milliseconds maximum.

For more information, contact your P&B sales engineer, or write Potter & Brumfield, Princeton, Indiana.



SL—dual coil latching relay. Operates on a 1 watt, 3 ms. pulse at nominal voltage. Permanent magnet latch locks the armature in either position.

SC—non-latching relay with series-connected dual coils. Operates on approximately 1 watt at nominal voltage. Coils must remain energized to hold the armature in the operate position.

SC and SL Series Engineering Data

GENERAL:

Insulation Resistance: 10,000 megohms, min.
Breakdown Voltage: 1,000 V. RMS.
Shock: 100g.
Vibration: 30g 55 to 2000 cps.; 0.195" max. excursions from 10-55 cps.
Temperature Range: —65° C. to + 125° C.
Weight: 15 grams without mounting bracket.
Operate Time: 3 MS. max. with 550 ohm coil @ 24 V. DC. (SL: 630 ohm coil at 24 V. DC).
Transfer Time: 0.5 MS max.
Terminals: (1) Plug-in for microminiature receptacle of printed circuit board.
(2) Hook end solder for 2 #24 AWG wires.
(3) 3" flexible leads.
Enclosure: Hermetically sealed.

CONTACTS:

Arrangement: 2 Form C.
Material: Gold flashed palladium.
Load: 2 amps @ 28 V. DC, resistive; 1 amp @ 115 V. 60 cycles AC, resistive.
Pressure: SC—16 grams min.; SL—20 grams min.

COIL:

Power: Approx. 1.0 watt at Nominal Voltage.
Resistance: SL—40 to 1400 ohms; SC—35 to 1250 ohms.
Duty: Continuous.

MOUNTINGS:

Bracket, stud and plug-in.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD INC.

PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

Circle 454 on Page 19

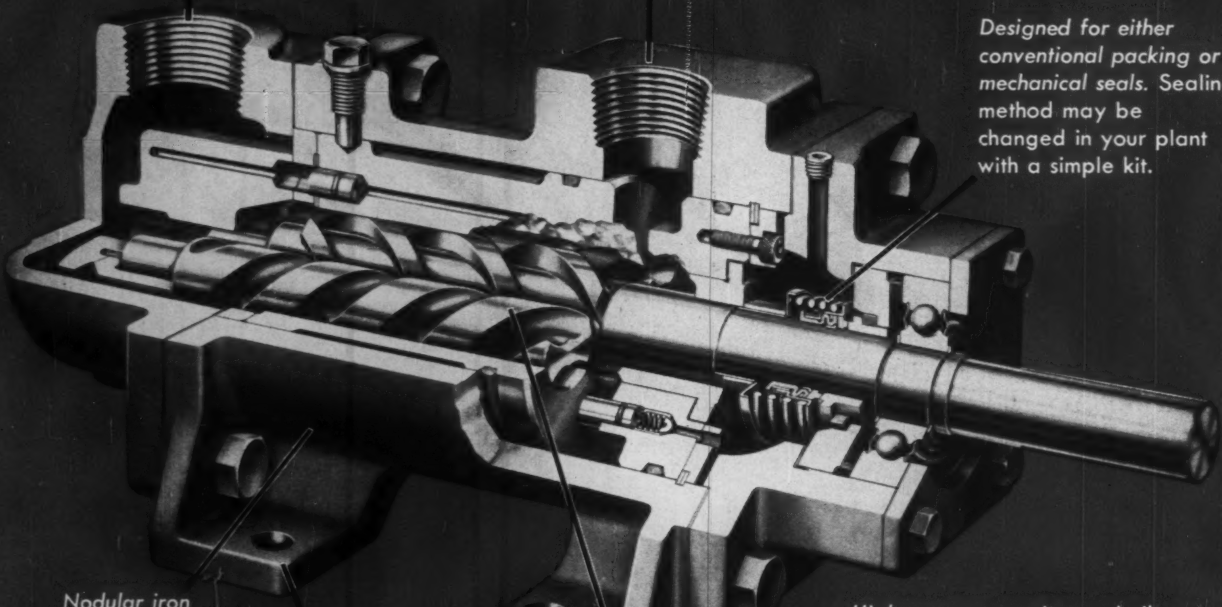
DE LAVAL
IMO PUMPS

are now more versatile than ever

De Laval IMO pumps have proved that they do a dependable job over long years of service. The reason is IMO design simplicity. These constant displacement rotary pumps have only three moving parts—smoothly intermeshing rotors that propel the fluid axially in a steady flow without churning, pocketing or pulsation. There are no timing gears, cams, valves, sliding vanes, or reciprocating parts to wear or become noisy. *Quiet*, compact IMO pumps are excellent for direct-connected, high-speed operation.

In addition to these basic pumping advantages, the improved IMO gives you important new benefits shown in the cutaway illustration below.

DE LAVAL IMO PUMPS can also be used as hydraulic motors.



Inlet can be rotated to suit installation arrangement.

Discharge flanges are infinitely varied. You can use the most advantageous piping method to suit installation requirements.

Designed for either conventional packing or mechanical seals. Sealing method may be changed in your plant with a simple kit.

Nodular iron casings for high pressure service have high shock capacity.

Any position mounting is possible without factory modification.

Higher pressure units are built by adding idler rotor and housing sections to the low pressure design. Parts for the same rotor size are interchangeable over the entire pressure range.

Internal parts are designed as a package so that units can be built into your machines.

Bulletin 3001 gives data on improved De Laval IMO pumps. Send for your copy today.

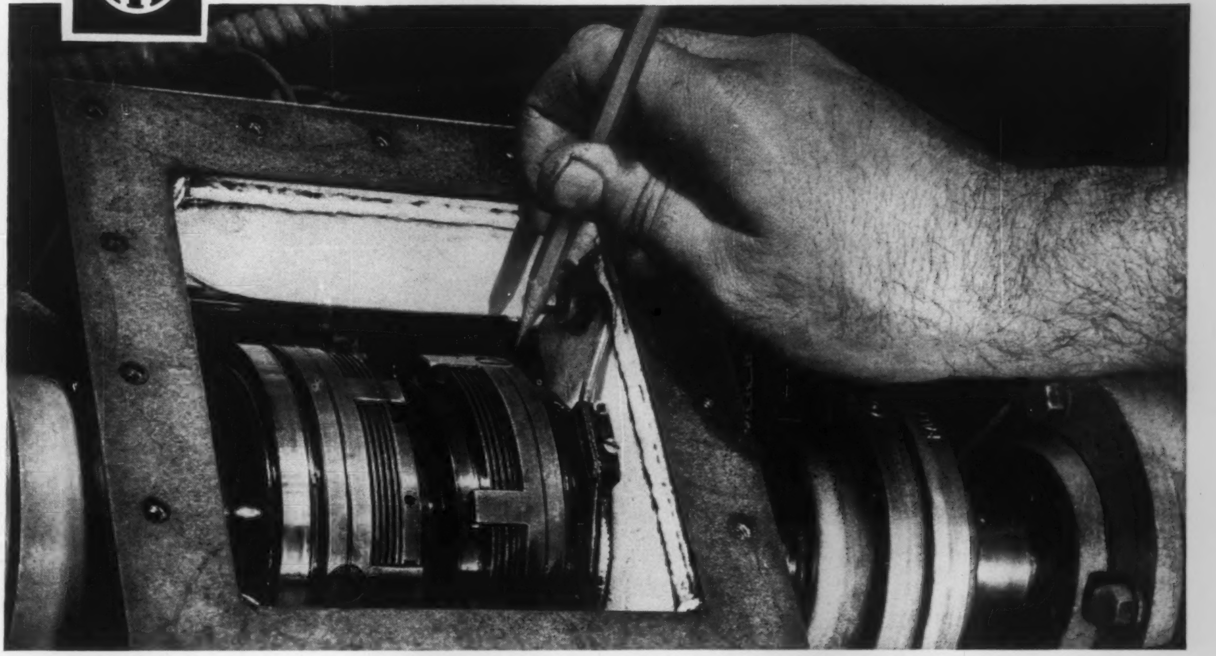
Please direct inquiries to advertiser, mentioning MACHINE DESIGN

DE LAVAL *IMO Pumps*

DE LAVAL STEAM TURBINE COMPANY
Nottingham Way, Trenton 2, New Jersey

DL 418

ELECTRO-CLUTCHES



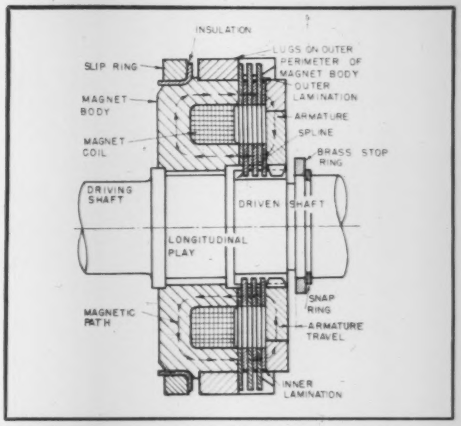
NO ADJUSTING

Get instant speed and feed changes for your machines without need for periodic checking and adjusting of clutches or gradual loss of torque. This is how: insist on genuine I-T-E Electro-Clutches.

No air gap. The patented closed magnetic circuit passing directly through the laminations provides tremendous torque in small space without need for maintaining precision air gaps. So the I-T-E Electro-Clutch goes right on giving uniform, troublefree clutching year in and year out.

More for your money. I-T-E Electro-Clutches are designed to operate in an oil bath. They can go right into your transmission box—often without altering dimensions. All-steel laminations outlast other clutch metals, plastics and friction discs—thus insuring longer clutch life. Safe 24 v operation permits use of telephone type relays, proved for dependability.

Select the exact clutch type you need from a wide range of stock models. For complete information, write I-T-E Circuit Breaker Company, Transformer & Rectifier Division, 19th & Hamilton Sts., Philadelphia 30, Pa.


INSULATION
SLIP RING
LUGS ON OUTER PERIMETER OF MAGNET BODY
OUTER LAMINATION
MAGNET BODY
ARMATURE
SPLINE
MAGNET COIL
BRASS STOP RING
DRIVING SHAFT
DRIVEN SHAFT
LONGITUDINAL PLAY
SNAP RING
MAGNETIC PATH
ARMATURE TRAVEL
INNER LAMINATION

Principle of operation. Alternate laminations key with perimeter lugs and splined shaft respectively. Rotate freely until magnet coil is energized. Magnetic flux attracts the armature, compressing the laminations with great force, engaging clutch.

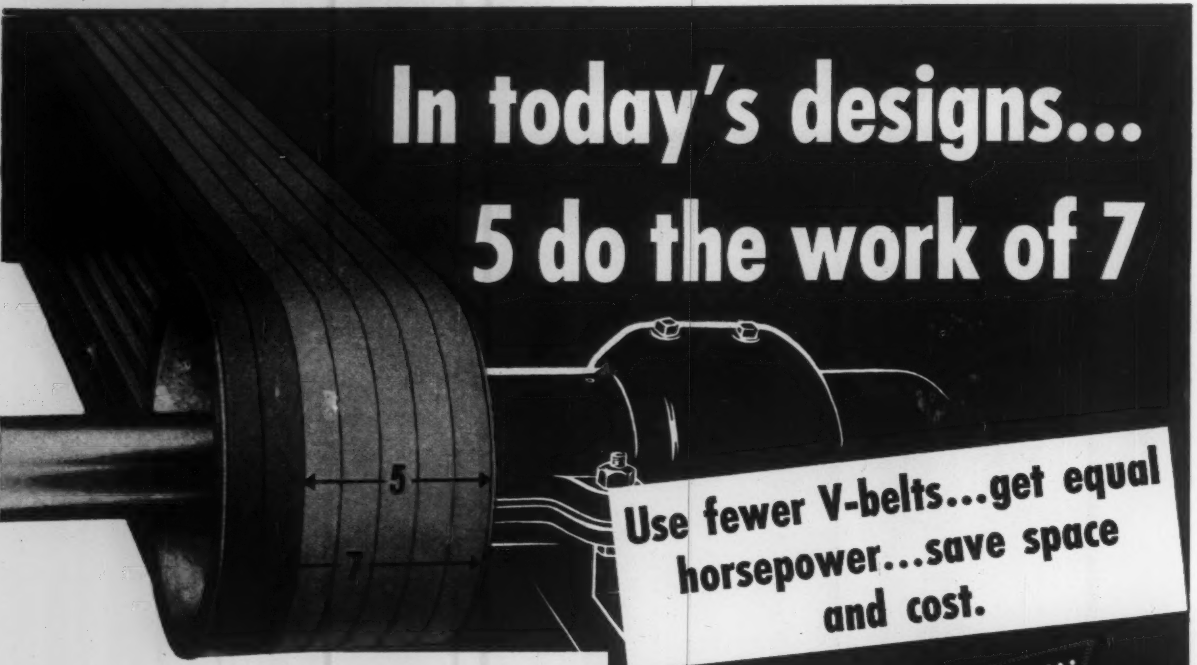
I-T-E Electro-Clutches are already in use by these leading companies:

Bullard Fosdick Sundstrand
Giddings & Lewis

I-T-E CIRCUIT BREAKER COMPANY
PHILADELPHIA, PENNSYLVANIA

Circle 455 on Page 19

In today's designs...
5 do the work of 7



Use fewer V-belts...get equal horsepower...save space and cost.

With 40% more horsepower, 5 Gates Super Vulco Ropes do the work of 7 standard V-belts... improve drive design. That's why—

A Super Vulco Rope Drive delivers more horsepower per dollar invested than any standard V-belt drive.

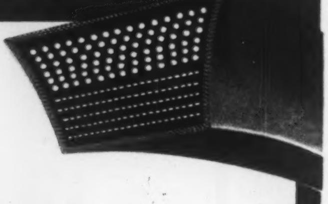
Comprehensive drive data is available to you quickly. Just call your nearby Gates distributor for a Gates V-Belt specialist. Stocks carried in industrial centers throughout the world.

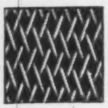
Gates Distributors are in the Yellow Pages

The Gates Rubber Company
Denver, Colorado
World's Largest Maker of V-Belts

Gates® The Mark of Specialized Research

No other V-Belt has ALL these advantages





1. Flex-Weave Cover (U.S. Pat. 2519590)
A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer... increases belt life... more power available to driven machine.

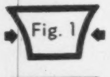


Fig. 1

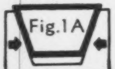
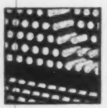


Fig. 1A

2. Concave Sidewalls (U.S. Pat. 1813698)
Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1A). Uniform contact means less wear on sides of belt... far longer belt life.



3. Tough, resilient Tensile Cords
Super-strong resilient tensile cords provide 40% greater horsepower capacity ... easily absorb heavy shock loads... reduce number of belts required... save weight and space.

4. High Electrical Conductivity
Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant
Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

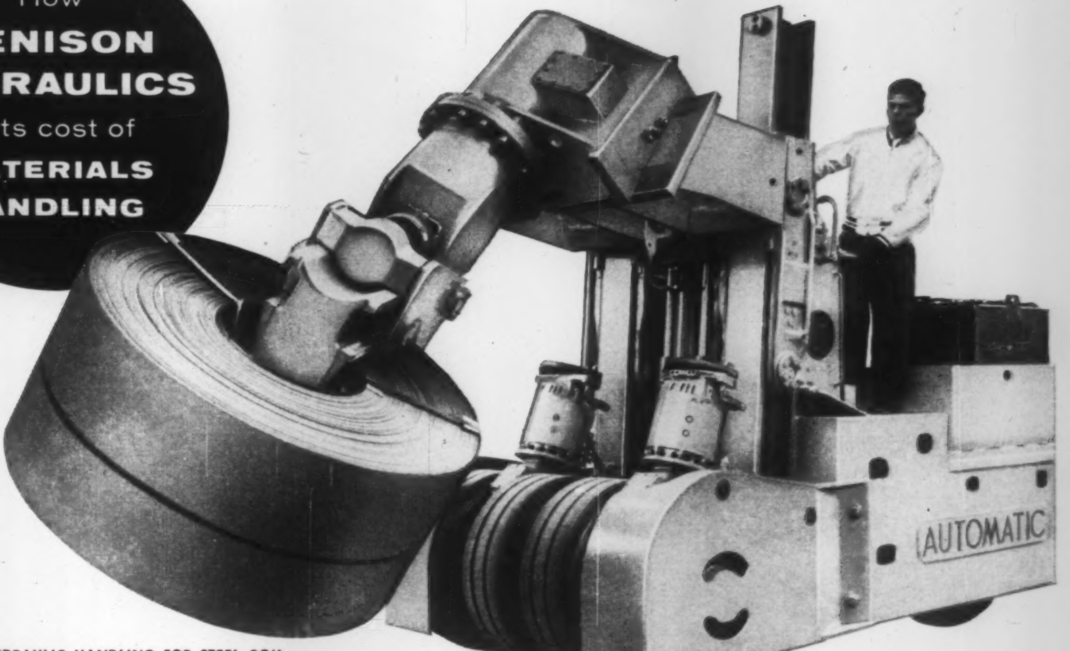
TPA 331

Gates Super V ULCO ROPE Drives

40% more Horsepower Capacity

Circle 456 on Page 19

How
DENISON HYDRAULICS
cuts cost of
MATERIALS HANDLING



SPEEDY HYDRAULIC HANDLING FOR STEEL COIL . . . *on a "Skylift Giant" heavy-duty truck developed by Automatic Transportation Co., Chicago, Division of Yale and Towne Mfg. Co. "Coil Up-ending Attachment"—powered by* ***Denison Axial Piston Pumps*** *—handles 10 to 40-ton loads of steel coil.*

AUTOMATIC® trucks handle steel coil like a baby . . . faster, safer with **DENISON** hydraulic power

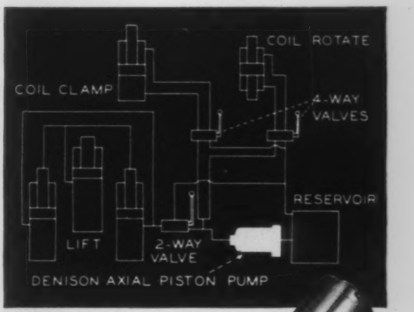
HERE'S the business end of a "Skylift Giant" industrial truck—equipped with a special "Coil Up-ending Attachment". Its jaws easily heft rolls of coiled steel weighing from 10 to 40 tons . . . *with Denison hydraulic power that pays off in smoother, faster, safer handling.*

In leading mills—these heavy-duty trucks speed handling and storage without damaging coils. The Coil Up-ending Attachment is designed to enter the coil's inside diameter with a fixed ram . . . while the outside is gripped by a powerful hydraulic clamp. This clamp-and-ram design prevents "telescoping" of coils during handling.

Three hydraulic cylinders—powered by motor-driven Denison 3000 psi Axial Piston Pumps—furnish lifting and clamping power. All three cylinders are connected hydraulically in parallel which results in a telescopic-cylinder action—but has the added advantage of retaining equal force and speed throughout the stroke at constant pressure and delivery.

Result: operator easily controls lowering speed at any level . . . and can inch the load up from extremely slow speed to maximum for which the flow control is set. *Safe, fast, smooth hydraulic control helps keep "Skylift" trucks continuously on the job . . . handling extra payload.*

Here's the kind of job your Denison Hydraulic Specialist can help *you* do *now.* Call him in soon . . . see how Denison hydraulic power can help put *more payload* into *your equipment.* Write us for details.



HYDRAULIC CIRCUIT DIAGRAM *. . . illustrates system for powering "Coil Up-ending Attachment". Denison equipment delivers hydraulic lifting and clamping power.*

DENISON 3000 PSI AXIAL PISTON PUMP

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

DENISON STOCKING BRANCH OFFICES

- **LOS ANGELES** (Hawthorne)
- **CHICAGO**
- **DETROIT** (Birmingham)
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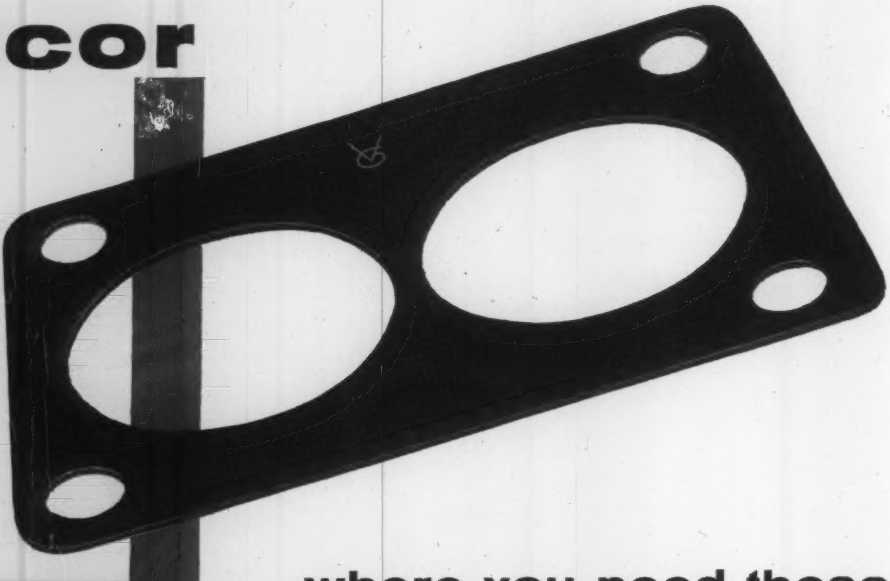
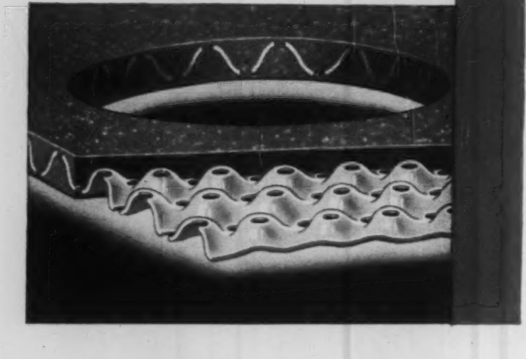
DENISON HydrOILics

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

Victocor

new super-sealing gasket material





Cross section of **Victocor.** Thin steel core is die-formed with continuous projections alternating in each face. (Type 200 core has 800 projections per sq. in.) Sealing element layers, top and bottom, are bonded simultaneously with core into integral structure. Deep penetration of core projections increases stability and heat conductivity.

TYPICAL PHYSICAL PROPERTIES — TYPE 200

Thickness	.030/.035" min.
% Compressibility at 1000 psi.	*10-15
% Recovery at 1000 psi.	35 min.
% Compressibility at 5000 psi.	*16-21
% Recovery at 5000 psi.	30 min.
Service temperature	750 deg. F.
Crush resistance psi.	100,000
Corrosion resistance against aluminum, magnesium, steel and copper	Good

*Slightly higher values are obtained with heavier gauge.

. . . where you need these maximum characteristics

- low torque loss
- high heat resistance
- high crush resistance
- high dimensional stability
- thin construction— .030/.035 gauge

Victocor justifies re-examination of your most exacting sealing specifications. It's a totally new product—offers more in every desirable heavy-duty characteristic.

Victocor was developed particularly for high-flange-pressure applications. Its steel core construction accelerates heat conductivity. It is strong and highly flexible.

Resistance to hot oils, gasoline and water is excellent, and **Victocor** positively retains all commonly used coolants.

Victocor's sealing element—a special asbestos-elastomeric compound—is extremely resilient. It helps compensate for mating surface irregularities. No coating is required when installing **Victocor** gaskets, and they're easily removed for replacement.

4 Standard Types Available—Test Samples Free

Where can you seal better and more economically with **Victocor?** Let Victor engineers help you decide. It's available in four standard types and many modified combinations. Meanwhile, write for complete technical data and free test samples. Please mention proposed application. Address the factory, or contact your Victor field engineer.

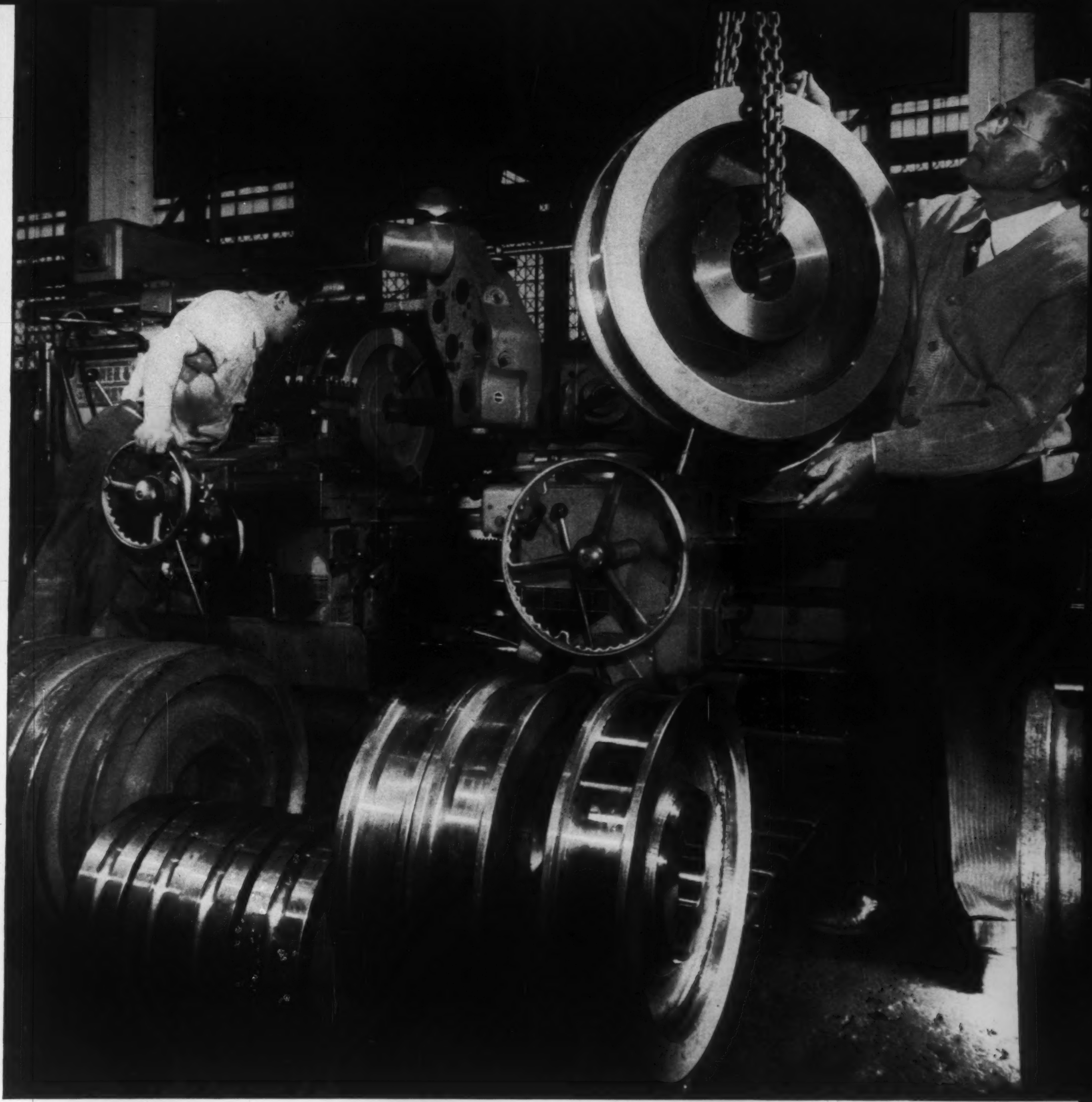
Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill.
Canadian Plant: St. Thomas, Ont.

VICTOR

Sealing Products *Exclusively*

GASKETS • PACKINGS • OIL SEALS • MECHANICAL SEALS

Circle 458 on Page 19



Good, Sturdy Blanks all the way through

Fine lot of crane wheels, aren't they? Beautifully machined. They look solid and strong and dependable all the way through. And they're just as sturdy as they look, for they're made from Bethlehem forged-and-rolled blanks.

Bethlehem's unique forging and rolling process imparts soundness, high strength, and excellent grain flow. It makes the machinist's job easier, less costly; the forgings have no hidden flaws to snag and slow the cutting tool.

For making circular steel parts, our forging and rolling process simply can't be surpassed. Bethlehem blanks are widely used in the making of heavy-duty gears, crane and sheave wheels, turbine rotors, flywheels, pipe flanges, and many other circular products. Available in either carbon or alloy steel, they can be furnished in a wide choice of sections and in sizes from 10 to 46 in. OD.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
***Export Distributor:* Bethlehem Steel Export Corporation**

BETHLEHEM STEEL

BETHLEHEM STEEL

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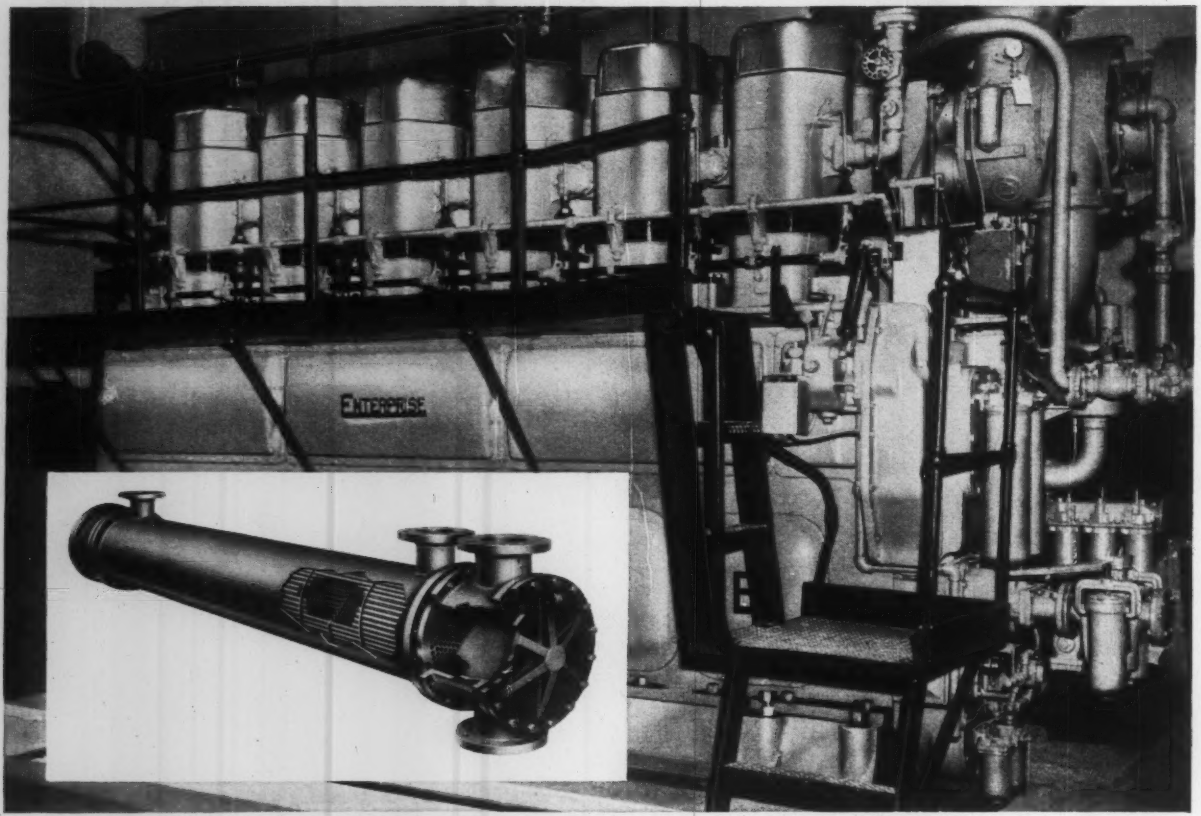
LUBE OIL COOLING BY ROSS



Heat's off on long runs

HIGH SPEEDS, stiff loads, and long continuous service won't take it out on bearings and other close clearance parts of *this* Enterprise engine . . . *the lube oil is Ross Exchanger cooled.* Installed recently at the Belleville, Kansas Power Plant, every working part of this 1455 hp unit is protected by an ample supply of oil at the *right* temperature and the *right* viscosity.

ONE OF THE BIG REASONS why the Enterprise Engine & Machinery Co. uses Ross Exchangers is that they are "recognized by consulting engineers as efficient and well built."

THIS SAME RUGGEDNESS and high thermal efficiency have earned a preference for Ross Exchangers among top-name builders in practically every field of application: engine, compressor, turbine, hydraulic machinery, speed changer, centrifugal pump . . . to cool oil, water, air, gas and hydraulic fluid.

HIGHLY ADAPTABLE and easy to install, compact Ross Exchangers are pre-engineered and fully standardized in a wide range of sizes to meet your heat transfer requirements.

Detailed information is in Bulletin 2.1K5. Write for your copy. American-Standard*, Ross Heat Exchanger Division, Buffalo 5, N. Y. In Canada: American-Standard Products (Canada) Limited, Station D, Toronto, Ont.

*American-Standard and Standard ® are trademarks of American Radiator & Standard Sanitary Corporation.

American-Standard Products

AMERICAN-Standard

ROSS HEAT EXCHANGER DIVISION

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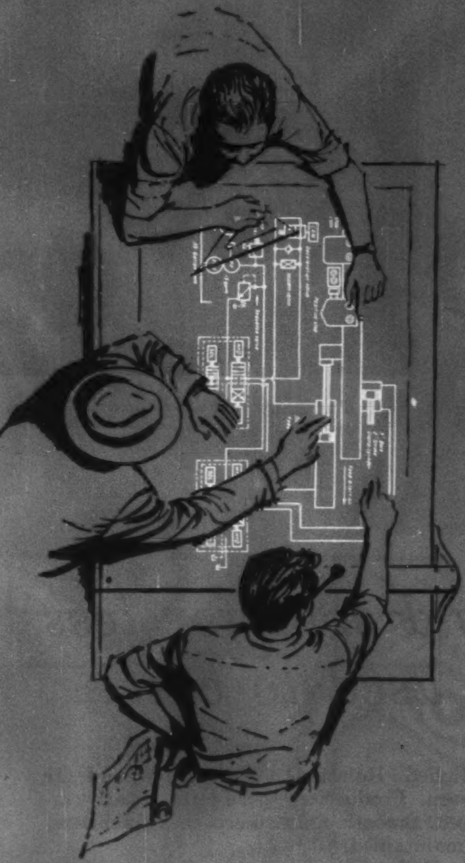
HYDRAULICS IN YOUR NEW DESIGN?



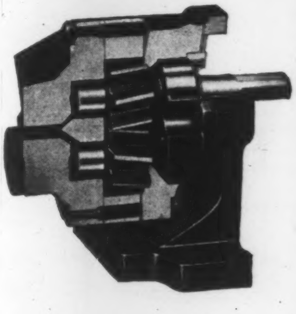
call the man from Webster

. . . and right at the start — before design problems pyramid costs and delay production. The man from Webster is a specially trained hydraulics engineer, armed with the latest technical know-how on hydraulic power application. He'll work with you, for you, to make hydraulics serve your product better. And, chances are, one of the more than 600 Webster pumps and fluid motors will be the key to successful, efficient operation.

OIL HYDRAULICS DIVISION

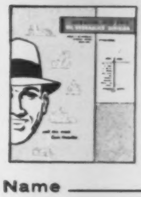
WEBSTER ELECTRIC
MELROSE 3-3611
RACINE · WIS

MORE THAN 600 WEBSTER PUMPS AND FLUID MOTORS



Capacities: *1/5 to 30 GPM*
Pressures: *Up to 1500 PSI*
Speeds: *Up to 3600 RPM*
Drives: *Direct or Geared*
Torques: *Up to 60 in. lbs./100 PSI*
Available with or without built-in relief valves

H-108



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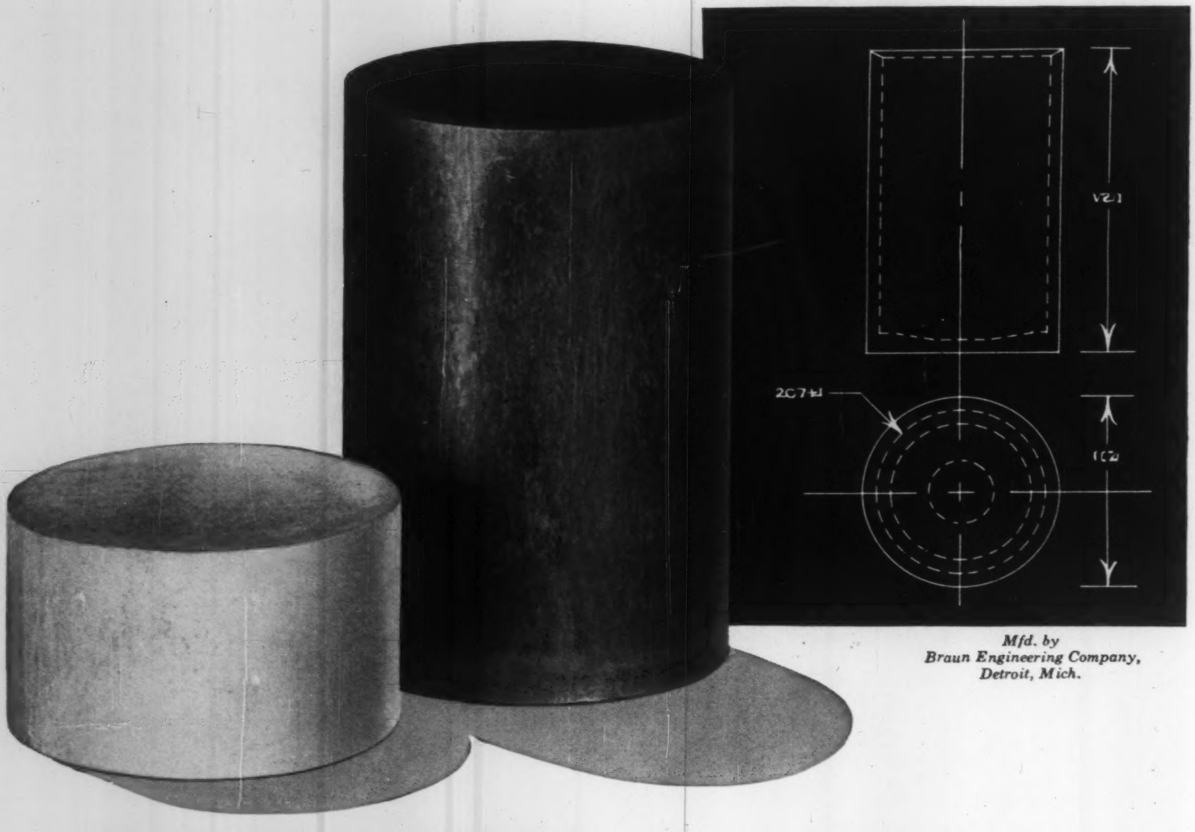

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EXTRUDED...*and sold for less than the raw stock used to cost!*

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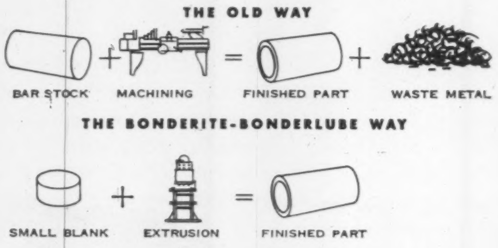
The Parker cold forming staff can give you expert help in the technique of cold extrusion.



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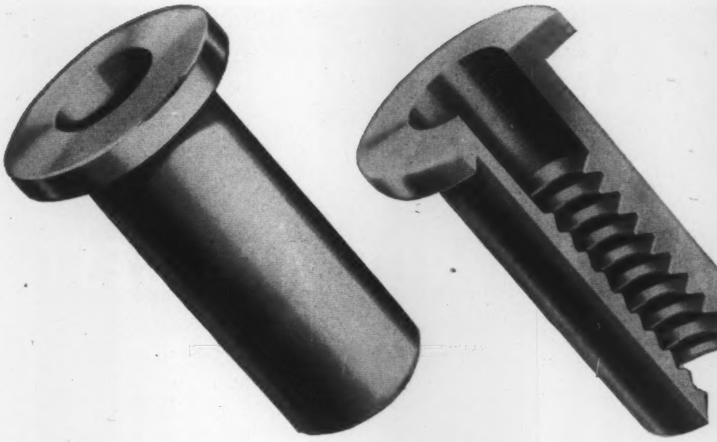

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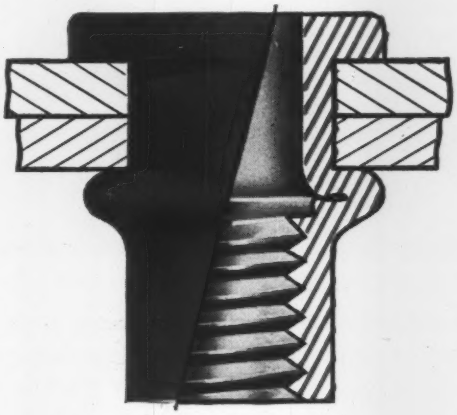
B. F. Goodrich Rivnuts®–the only one-piece blind fasteners with threads

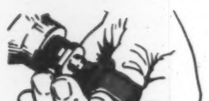


If you have a fastening problem, solve it the easy way—with B.F.Goodrich Rivnuts. One man can install Rivnuts from one side of the work. It takes only a few seconds—speeds assembly and cuts costs as much as 50 to 90% depending upon the application.

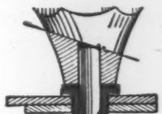
Rivnuts are stronger, too, because they provide at least 6 clean threads, even in thin sheet metal. By eliminating welding, tapping and cleaning, B.F.Goodrich Rivnuts eliminate costly steps in production and straighten out assembly lines.

Rivnuts come in a variety of types, sizes and materials to solve your specific fastening problem, whether you are working with sheet metal, wood or plastic. For complete information, send for the free Rivnut Demonstrator. It shows with motion how Rivnuts fasten *to* and *with*. Write: B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. MD-78, Akron, Ohio.

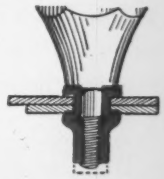
Rivnuts provide at least 6 clean threads in one simple operation



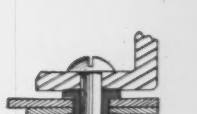
1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2 Rivnut is inserted—head firmly against work — tool at right angles to work.



3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

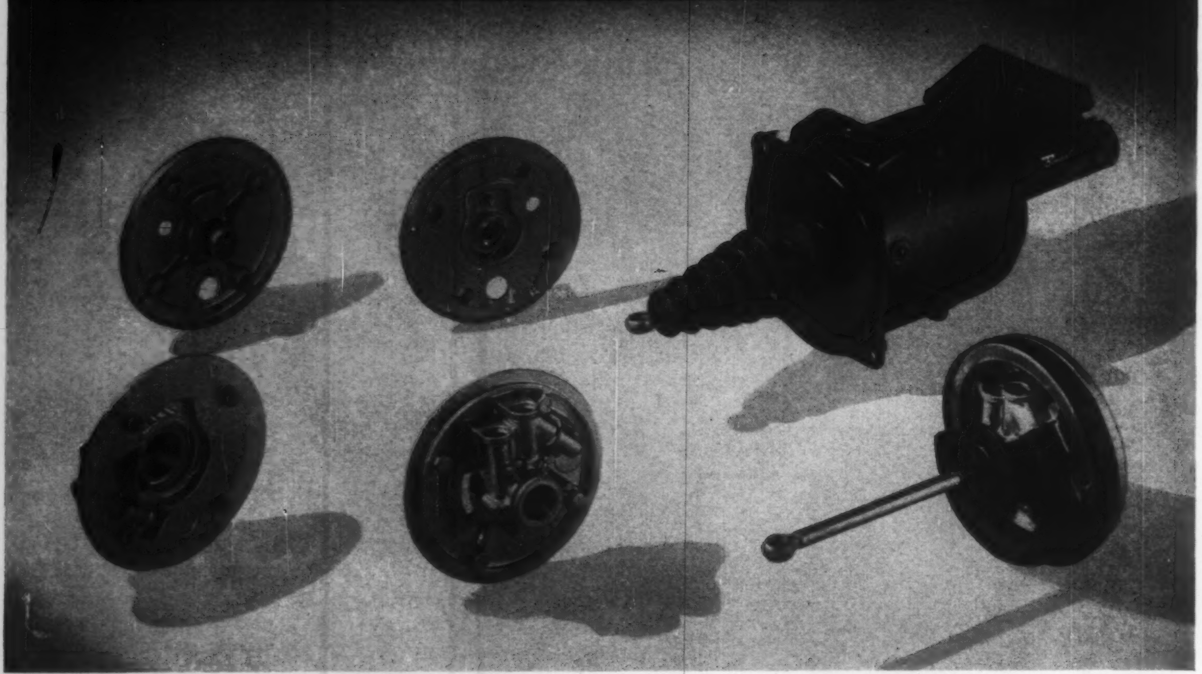


4 After upset, Rivnut threads are still clean and intact ready for screw attachment.

B.F.Goodrich aviation products

FOR Eliminating Extra Parts AND Extra Machining

ZINC DIE CASTINGS ARE BEST



Bendix engineers designed this piston and control valve assembly for the Treadle-Vac Power Brake so the entire mechanism could be built around these two intricate ZINC Die Castings.

Extra parts—as well as extra machining—were eliminated by the use of ZINC Die Castings.

Front and back views of the two castings show the cored holes and bosses used in locating and fitting the internal parts. Both plates are quickly prepared for assembly by a single machining operation and locked together as a unit containing the poppet valves, springs, diaphragms and other necessary equipment.

Bendix engineers gained additional advantages by using ZINC Die Castings. Ribbing, for instance, permitted the use of metal-saving thin wall sections while providing more than ample strength for the job. They knew, from previous experience, that die life is longer with ZINC than with other die casting materials.

Why not see your die caster and find out how such parts-saving and time-saving advantages can be used in your products?

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Circle 464 on Page 19

MACHINE DESIGN
July 10, 1958

Do It Yourself?

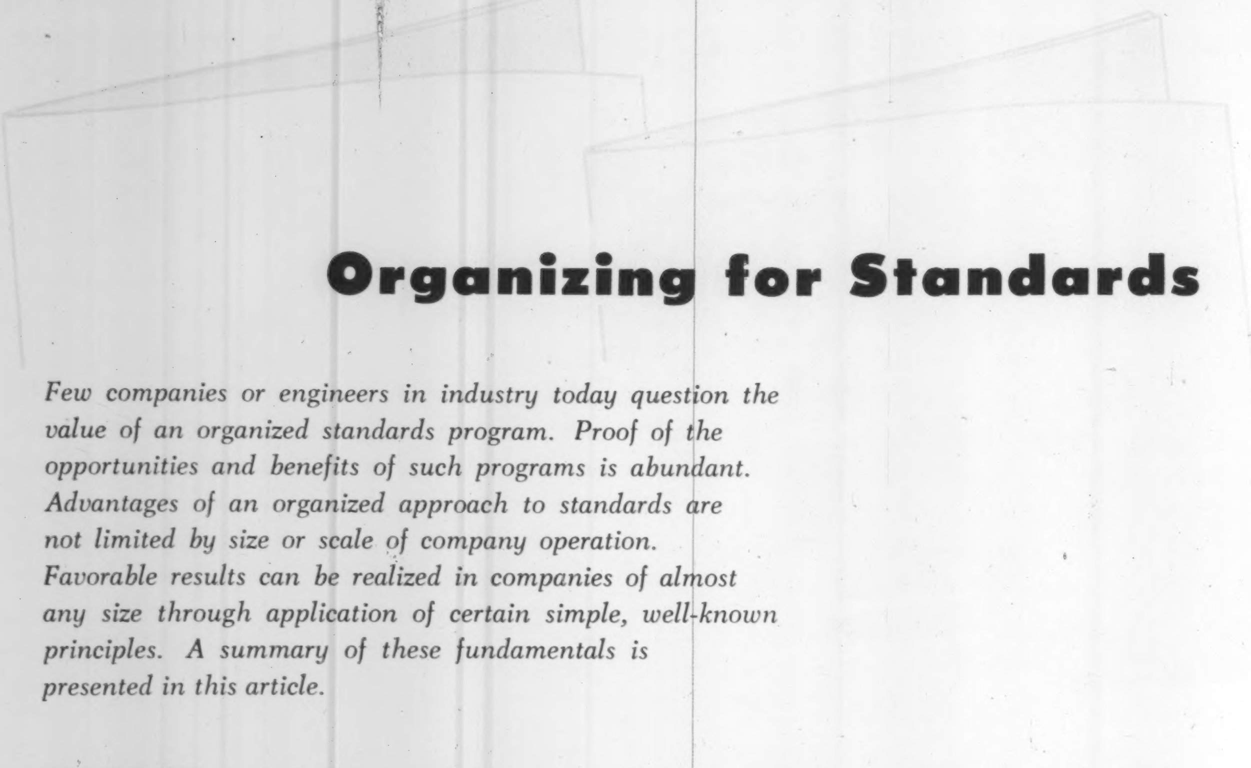
IT WAS Joe's first design, and it was a honey. But it never got beyond the assistant chief's desk. Why? Joe had carefully calculated his proportions to meet service requirements. But too many of the resulting dimensions called for nonstandard components. Some changes here and there that would have added maybe ten per cent to the weight would have made possible the use of standard parts already in inventory. Net cost savings could have amounted to almost twenty per cent.

Joe would have made these changes cheerfully when they were pointed out to him, but the biggest blow was yet to come. In giving him the assignment, his supervisor had overlooked the fact that the function of the subassembly was duplicated by a unit available from another manufacturer. A memo from the engineering department to the purchasing agent took the place of many engineering manhours. And because the other manufacturer produced the unit in quantity, the purchase price was less then the cost of manufacture in the shops of Joe's company.

The double-barreled lesson was not lost on Joe. His standards-consciousness has since saved his company thousands of dollars. His philosophy is: Why do it yourself if somebody else has already done it? Time thus saved has gone into new creative design—designing what hasn't been designed before.

Like laws and ordinances, standards are designed for the common good. Likewise they must always be dynamic, must continue to meet the current needs of both producers and customers. Existence of a standard—national, industry-wide, or company—does not absolve the design engineer of responsibility for economic and other consequences of its use in his design. So Joe tempers his advocacy of standardization with the warning: If you can do it better, don't hesitate to do it yourself.

Colin Carmichael
EDITOR



Organizing for Standards

Few companies or engineers in industry today question the value of an organized standards program. Proof of the opportunities and benefits of such programs is abundant. Advantages of an organized approach to standards are not limited by size or scale of company operation. Favorable results can be realized in companies of almost any size through application of certain simple, well-known principles. A summary of these fundamentals is presented in this article.

COMPANY standards fall generally into two broad classes: Managerial and technical. Managerial standards are concerned with company organizational practices, worker's performance, accounting procedures, personnel policies, and any other activities not directly connected with a product or manufacturing process.

Technical standards are concerned with products, manufacturing processes, materials, supply specifications, and design, drafting, and safety practices. They may also define the components of a product, and its composition in terms of size, shape, color, material, quality, and performance characteristics. In a general sense these standards fit into the broad category of engineering, industrial, safety, and consumer type standards.

In this article, attention will be focused on the second group—technical standards—with specific emphasis on engineering and industrial standards as compared to safety or consumer types. However, the basic principles are applicable to any program of standards organization.

How does a company start a standards program? Once the decision to support a standards program has been made, the task of establishing this program requires careful consideration of a number of factors. Several key areas require decisions:

1. What type of a standards organization shall be adopted?
2. If a separate standards department is to be organized, where will it fall within the company organization?
3. What areas shall be covered by the standards program?
4. What shall be the operating procedure?
5. How shall the program be staffed?
6. What sources of information will be used for the standards?

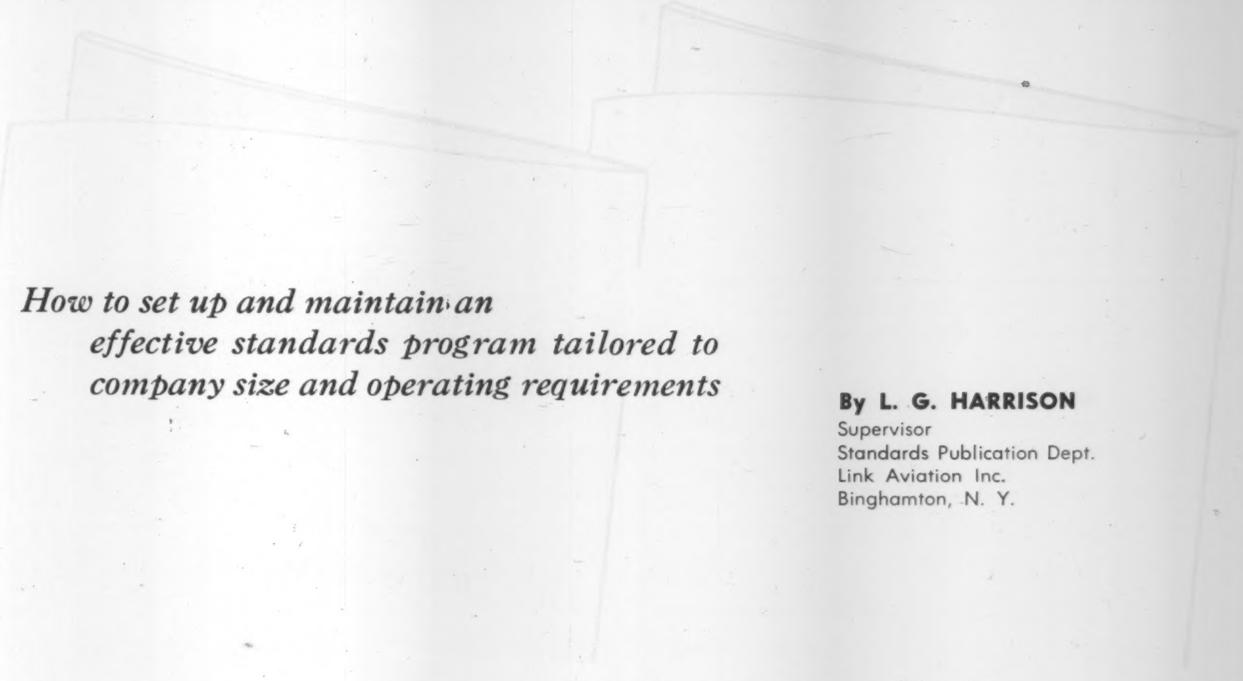
These questions pinpoint the main areas of attention. However, the list can and, perhaps, should be expanded to include other items dealing with specific individual needs.

▶ Type of Standards Organization

Standards programs can be organized along two basic lines. The first is the informal organization in which standards are assigned to particular groups for preparation but are co-ordinated under a key executive or manager. The second is the formal standards organization, on a department or group basis, which is staffed with standards engineers and necessary clerical help. In large and small companies alike, both types of standard organizations are found.

The informal type of program is, of course, the easiest to establish. With this form of organization, when a design standard is needed, a designer is assigned to its preparation. When a drafting standard is needed, a draftsman is assigned to the job. A chief engineer of a leading aircraft parts company emphasizes this point: "Design engineers, project engineers, manufacturing engineers, and supervision are constantly aware of the necessity for preventing the use of nonstandard items wherever possible. Consequently, greater effectiveness is achieved in this manner than in having a segregated group working on standards." Many companies share the view that as good or better results can be achieved by handling standards activities through regular divisional or department channels than by setting up a staff group or a standards department for this work.

In the formal standards organization, authority



How to set up and maintain an effective standards program tailored to company size and operating requirements

By L. G. HARRISON
Supervisor
Standards Publication Dept.
Link Aviation Inc.
Binghamton, N. Y.

is delegated to the person in charge of the standards department. This person is responsible for all standards, as well as for the personnel compiling, preparing, and distributing the approved standards. This type of organization has a definite place in the company structure. As a department, it can (1) operate on an established budget, (2) have a voice in matters pertaining to standards through the department supervisor or manager, and (3) prepare a work schedule.

Sources of Standards

American Gear Manufacturers Association (AGMA)
One Thomas Circle, Washington, D. C.

American Institute of Electrical Engineers (AIEE)
33 W. 39th St., New York, N. Y.

American Society of Mechanical Engineers (ASME)
29 W. 39th St., New York, N. Y.

American Society for Testing Materials (ASTM)
1916 Race St., Philadelphia, Pa.

American Standards Association (ASA)
70 E. 45th St., New York, N. Y.

American Welding Society (AWS)
29 W. 39th St., New York, N. Y.

Electronic Industries Association (EIA)
11 W. 42nd St., New York, N. Y.

Industrial Fasteners Institute (IFI)
1517 Terminal Tower, Cleveland, Ohio

Institute of Radio Engineers (IRE)
1 E. 79th St., New York, N. Y.

Joint Industry Conference (JIC)
Box 182, Northend Station, Detroit, Mich.

National Electrical Manufacturers Association (NEMA)
155 E. 44th St., New York, N. Y.

National Machine Tool Builders Association (NMTBA)
2071 E. 102nd St., Cleveland, Ohio

Society of Automotive Engineers Inc. (SAE)
485 Lexington Ave., New York 17, N. Y.

As mentioned before, the easiest type of standard to prepare is one in which responsibility is assigned to a particular group, as in the informal approach. Certain other aspects of such systems also deserve consideration.

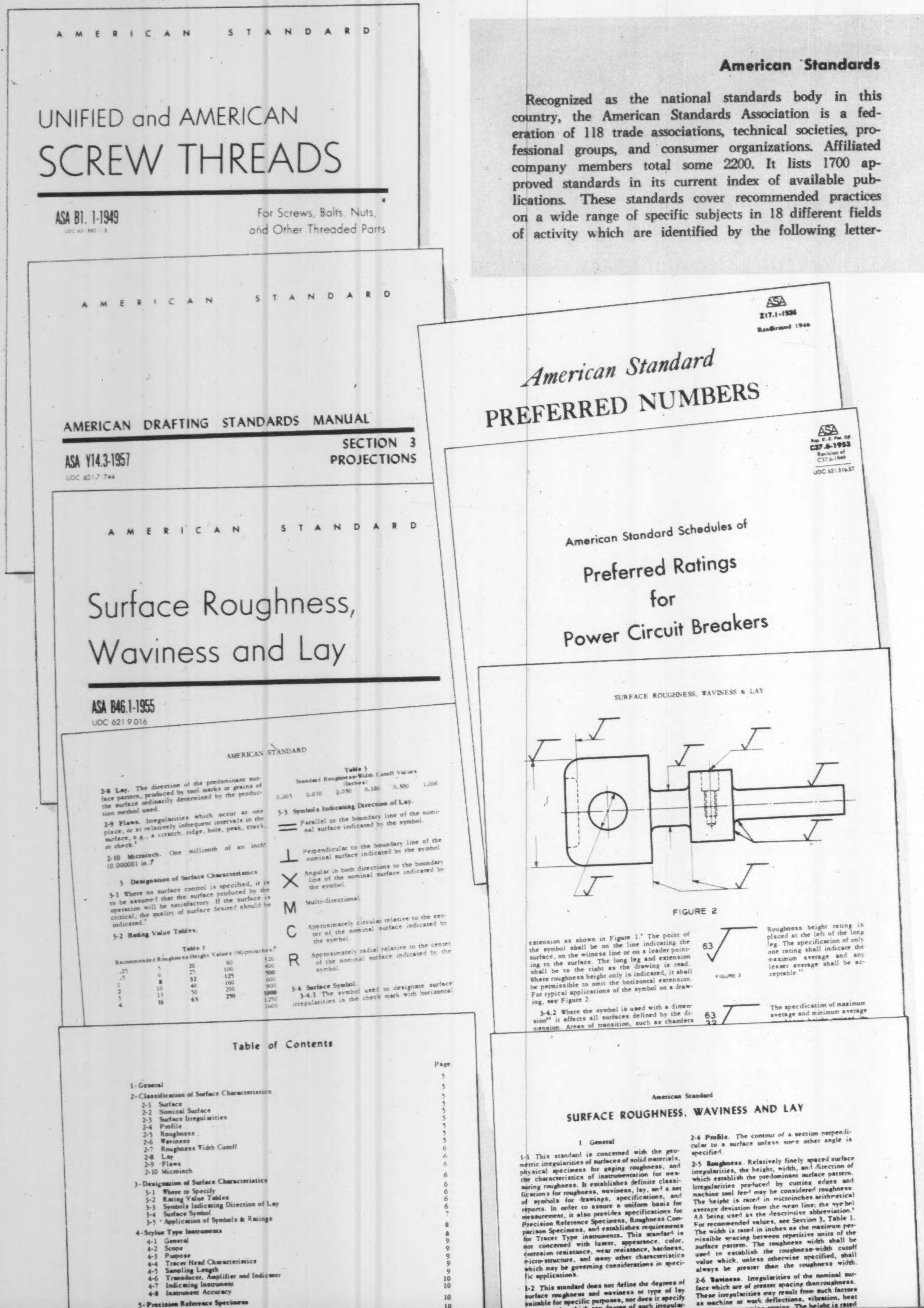
1. When an engineering standard is required, it generally affects both design and drafting operations. Under the informal type of program it would be possible to have either a design standard with no control for application of the design to a production drawing or an engineering standard with no manufacturing interpretation. When a standard is required, it should be prepared to cover all necessary phases (design, drafting, shop, inspection, etc.) and to describe to each department the method each should follow in applying the new standard effectively.

2. If it is the responsibility of a functional company group to prepare standards, standards will generally fare second best. Suppose it is necessary to develop a design standard and the task is assigned to a designer. Under the circumstances, his natural tendency will be to get the standard written as quickly as possible so he can return to his main job activity of design. Or, as often happens, the situation may be that a designer is assigned to work on a standard whenever he can with instructions not to let such work interrupt his main job for too long a period at a time. Can this approach produce a thoroughly investigated standard?

3. Once a standard has been prepared, arrangements must be made for printing and distribution.

American Standards

Recognized as the national standards body in this country, the American Standards Association is a federation of 118 trade associations, technical societies, professional groups, and consumer organizations. Affiliated company members total some 2200. It lists 1700 approved standards in its current index of available publications. These standards cover recommended practices on a wide range of specific subjects in 18 different fields of activity which are identified by the following letter-



AMERICAN STANDARD

UNIFIED and AMERICAN
SCREW THREADS

ASA B1. 1-1949
UDC 621.882.1.3

For Screws, Bolts, Nuts,
and Other Threaded Parts

AMERICAN STANDARD

AMERICAN DRAFTING STANDARDS MANUAL

ASA Y14.3-1957
UDC 621.7.744

SECTION 3
PROJECTIONS

AMERICAN STANDARD

Surface Roughness,
Waviness and Lay

ASA B46.1-1955
UDC 621.9.016

AMERICAN STANDARD

2-8 Lay. The direction of the predominant surface pattern, produced by tool marks or grains of the surface ordinarily determined by the production method used.

2-9 Flaws. Irregularities which occur at one place, or at relatively infrequent intervals in the surface, e.g., a scratch, ridge, hole, peak, crack, or check.[5]

2-10 Microinch. One millionth of an inch (0.000001 in.)[6]

3 Designation of Surface Characteristics

3-1 Where no surface control is specified, it is to be assumed that the surface produced by the operation will be satisfactory. If the surface is critical, the quality of surface desired should be indicated.[7]

3-2 Rating Value Tables.

Table 1
Recommended Roughness Height Values (Microinches)[8]

.25	5	20	80	320
.5	6	25	100	400
1	8	32	125	500
2	10	40	160	600
3	13	50	200	800
4	16	63	250	1000
				1250
				1600

Table 3
Standard Roughness-Width Cutoff Values
(Inches)

0.003	0.010	0.030	0.100	0.300	1.000

3-3 Symbols Indicating Direction of Lay.

═ Parallel to the boundary line of the nominal surface indicated by the symbol.

⊥ Perpendicular to the boundary line of the nominal surface indicated by the symbol.

X Angular in both directions to the boundary line of the nominal surface indicated by the symbol.

M Multi-directional.

C Approximately circular relative to the center of the nominal surface indicated by the symbol.

R Approximately radial relative to the center of the nominal surface indicated by the symbol.

3-4 Surface Symbol.

3-4.1 The symbol used to designate surface irregularities is the check mark with horizontal

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ASA
Z17.1-1936
Reaffirmed 1946

American Standard
PREFERRED NUMBERS

ASA
Reg. U. S. Pat. Off.
C37.6-1953
Revision of
C37.6-1949
UDC 621.316.57

American Standard Schedules of
Preferred Ratings
for
Power Circuit Breakers

SURFACE ROUGHNESS, WAVINESS & LAY

FIGURE 2

extension as shown in Figure 1.[9] The point of the symbol shall be on the line indicating the surface, on the witness line or on a leader pointing to the surface. The long leg and extension shall be to the right as the drawing is read. Where roughness height only is indicated, it shall be permissible to omit the horizontal extension. For typical applications of the symbol on a drawing, see Figure 2.

3-4.2 Where the symbol is used with a dimension[10] it affects all surfaces defined by the dimension. Areas of transition, such as chamfers

FIGURE 3

Roughness height rating is placed at the left of the long leg. The specification of only one rating shall indicate the maximum average and any lesser average shall be acceptable.[11]

The specification of maximum average and minimum average

American Standard

SURFACE ROUGHNESS, WAVINESS AND LAY

1 General

1-1 This standard is concerned with the geometric irregularities of surfaces of solid materials, physical specimens for gaging roughness, and the characteristics of instrumentation for measuring roughness. It establishes definite classifications for roughness, waviness, lay, and a set of symbols for drawings, specifications, and reports. In order to assure a uniform basis for measurement, it also provides specifications for Precision Reference Specimens, Roughness Comparison Specimens, and establishes requirements for Tracer Type instruments. This standard is not concerned with luster, appearance, color, corrosion resistance, wear resistance, hardness, micro-structure, and many other characteristics which may be governing considerations in specific applications.

1-2 This standard does not define the degrees of surface roughness and waviness or type of lay suitable for specific purposes, nor does it specify

2-4 Profile. The contour of a section perpendicular to a surface unless some other angle is specified.

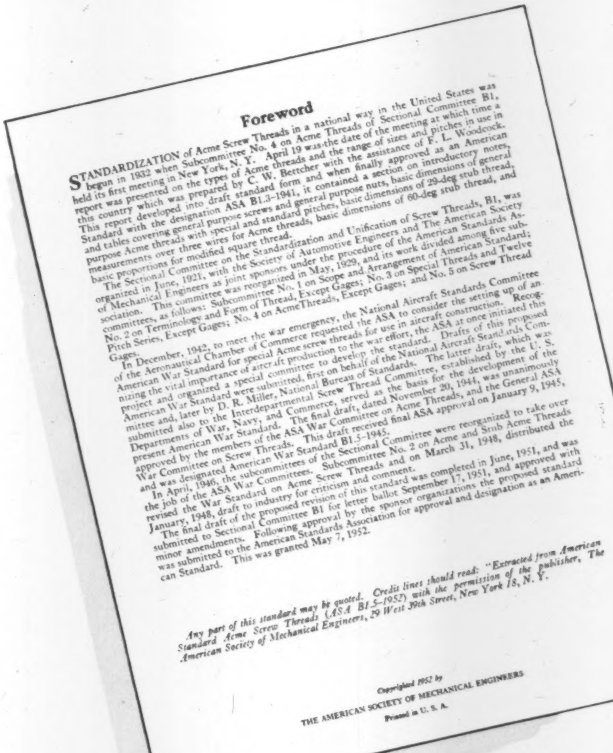
2-5 Roughness. Relatively finely spaced surface irregularities, the height, width, and direction of which establish the predominant surface pattern. Irregularities produced by cutting edges and machine tool feed may be considered roughness. The height is rated in microinches arithmetical average deviation from the mean line; the symbol AA being used as the descriptive abbreviation.[4] For recommended values, see Section 3, Table 1. The width is rated in inches as the maximum permissible spacing between repetitive units of the surface pattern. The roughness width shall be used to establish the roughness-width cutoff value which, unless otherwise specified, shall always be greater than the roughness width.

2-6 Waviness. Irregularities of the nominal surface which are of greater spacing than roughness. These irregularities may result from such factors as machine or work deflections, vibration, heat code system of reference:

Automotive	**D**
Chemical Industry	**K**
Civil Engineering and Construction	**A**
Commercial Standards	**CS**
Drawings, Symbols, and Abbreviations	**Y**
Electrical Engineering	**C**
Ferrous Materials and Metallurgy	**G**
Mechanical Engineering	**B**
Mining	**M**
Miscellaneous	**Z**
Nonferrous Materials and Metallurgy	**H**
Nuclear	**N**
Office Equipment and Supplies	**X**
Photography and Motion Pictures	**PH**
Pulp and Paper Industry	**P**
Rubber	**J**
Textile Industry	**L**
Wood Industry	**O**

The ASA classification system for standards is based on a letter-number sequence. The letter identifies the appropriate field according to the foregoing code, and is followed by two numbers separated by a hyphen. The number preceding the hyphen is a classifying number corresponding to the sectional committee responsible for the standard; the number following the hyphen is the year in which the standard was approved. Thus, ASA B3.5-1951 (*American Standard Tolerances for Ball and Roller Bearings*) identifies a Mechanical Engineering standard developed by sectional committee B3 on ball and roller bearings, and approved in 1951.

Typical American Standards shown here, which represent four of the code-letter groups, illustrate the diversity of subject treatment. Conventional form of published information is exemplified by the pages from *American Standard Surface Roughness, Waviness and Lay* (ASA B46.1-1955).



Foreword

STANDARDIZATION of Acme Screw Threads in a national way in the United States was begun in 1932 when Subcommittee No. 4 on Acme Threads of Sectional Committee B1, held its first meeting in New York, N. Y. April 19 was the date of the meeting at which time a report was presented on the types of Acme threads and the range of sizes and pitches in use in this country which was prepared by C. W. Bettcher with the assistance of F. L. Woodcock. This report developed into draft standard form and when finally approved as an American Standard with the designation ASA B1.3-1941, it contained a section on introductory notes, and tables covering general purpose screws and general purpose nuts, basic dimensions of general purpose Acme threads with special and standard pitches, basic dimensions of 29-deg stub thread, measurements over three wires for Acme threads, basic dimensions of 60-deg stub thread, and basic proportions for modified square thread.

The Sectional Committee on the Standardization and Unification of Screw Threads, B1, was organized in June, 1921, with the Society of Automotive Engineers and The American Society of Mechanical Engineers as joint sponsors under the procedure of the American Standards Association. This committee was reorganized in May, 1929, and its work divided among five subcommittees, as follows: Subcommittee No. 1 on Scope and Arrangement of American Standard; No. 2 on Terminology and Form of Thread, Except Gages; No. 3 on Special Threads and Twelve Pitch Series, Except Gages; No. 4 on AcmeThreads, Except Gages; and No. 5 on Screw Thread Gages.

In December, 1942, to meet the war emergency, the National Aircraft Standards Committee of the Aeronautical Chamber of Commerce requested the ASA to consider the setting up of an American War Standard for special Acme screw threads for use in aircraft construction. Recognizing the vital importance of aircraft production to the war effort, the ASA at once initiated this project and organized a special committee to develop the standard. Drafts of this proposed American War Standard were submitted, first on behalf of the National Aircraft Standards Committee and, later by D. R. Miller, National Bureau of Standards. The latter draft, which was submitted also to the Interdepartmental Screw Thread Committee, established by the U. S. Departments of War, Navy, and Commerce, served as the basis for the development of the present American War Standard. The final draft, dated November 20, 1944, was unanimously approved by the members of the ASA War Committee on Acme Threads, and the General ASA War Committee on Screw Threads. This draft received final ASA approval on January 9, 1945, and was designated American War Standard B1.5-1945.

In April, 1946, the subcommittees of the Sectional Committee were reorganized to take over the job of the ASA War Committees. Subcommittee No. 2 on Acme and Stub Acme Threads revised the War Standard on Acme Screw Threads and on March 31, 1948, distributed the January, 1948, draft to industry for criticism and comment.

The final draft of the proposed revision of this standard was completed in June, 1951, and was submitted to Sectional Committee B1 for letter ballot September 17, 1951, and approved with minor amendments. Following approval by the sponsor organizations the proposed standard was submitted to the American Standards Association for approval and designation as an American Standard. This was granted May 7, 1952.

Any part of this standard may be quoted. Credit lines should read: "Extracted from American Standard Acme Screw Threads (ASA B1.5-1952) with the permission of the publisher, The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y.

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These are some of the more important considerations in establishing a standards organization. Final

How American Standards Are Developed

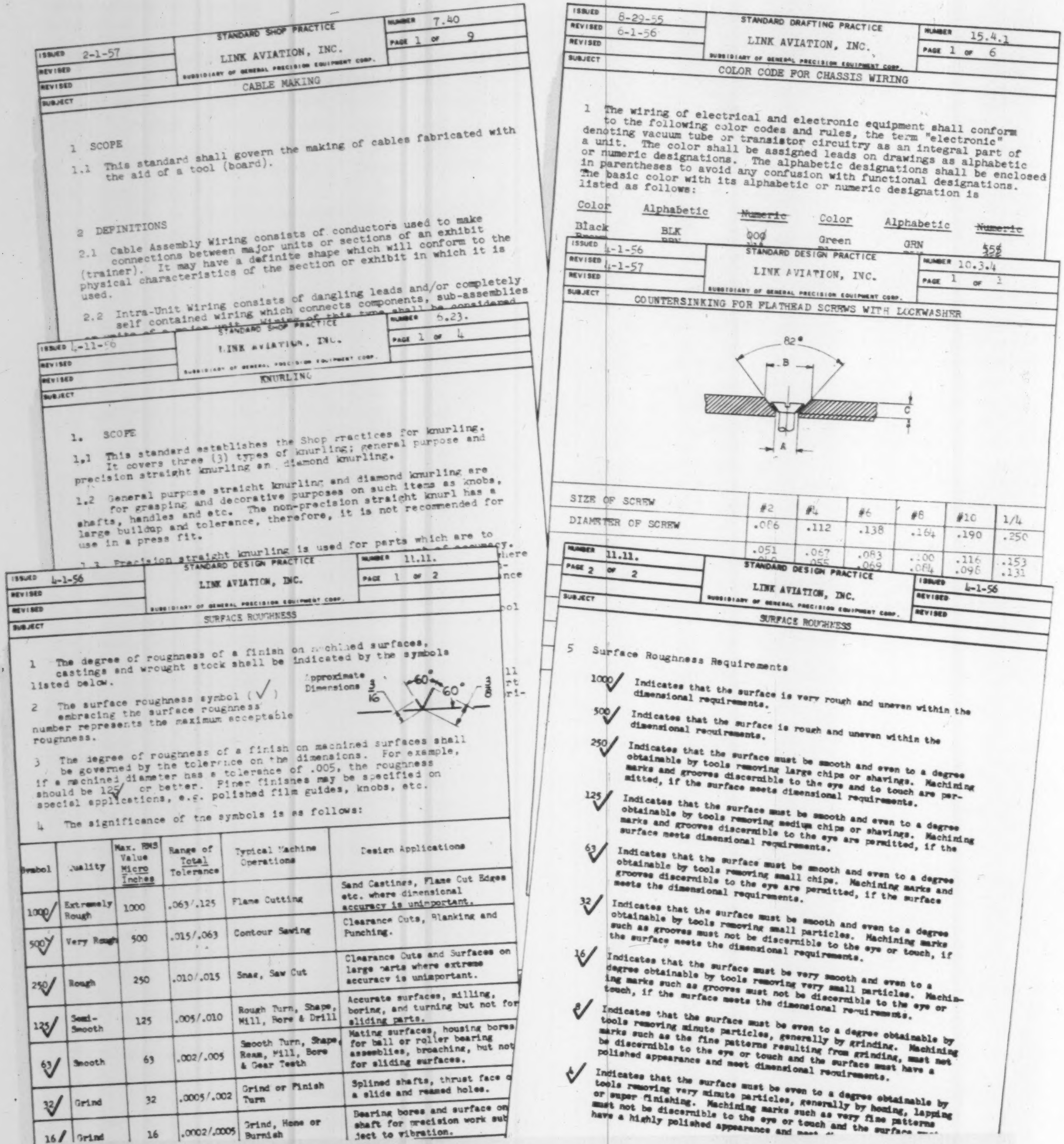
Three basic methods are employed for the development of an American Standard, once the need for the standard has been established by consensus of all interested parties. These same methods can also be used for revision of standards. However, a competent, recognized group may be assigned the responsibility for revising a standard under its own procedures and for submitting the modified version to ASA for designation as an American Standard.

Sectional Committee Method: In this approach, responsibility for development of a standard is in the hands of one or more sponsor organizations, such as professional societies or trade associations. A sectional committee is organized to draft a standard which is then submitted to all interested parties for review and comment. Necessary revisions are incorporated and a final draft is submitted to the committee for letter ballot. When a consensus is obtained, the draft is turned over to ASA for approval as an American Standard.

Existing Standards Method: An existing standard of any organization may be submitted to ASA for approval as an American Standard without going through any of the other recognized channels. If the standard is truly national in scope and recognition, does not conflict with other standards in its field, and proof can be shown of its acceptance by those substantially concerned with its application, it will be approved. A noteworthy example of a group that frequently uses this method of approach for standards recognition is the American Society for Testing Materials.

General Acceptance Method: For comparatively simple projects which do not require prolonged technical discussions, a third approach is possible. With this method, a general conference of interested organizations is called to discuss the proposed subject and formulate a standard. When a consensus is obtained, the standard is submitted to ASA for approval. Development of a standard inch-millimeter conversion factor (1 in. = 25.4 mm) was based on this method of approach.

For American Standards, development history of each standard is given on the "Foreword" page. The page shown here was taken from *American Standard Acme Screw Threads* (ASA (B1.5-1952) which contains some 41 pages.



ISSUED 2-1-57
REVISED
REVISED
SUBJECT
STANDARD SHOP PRACTICE
LINK AVIATION, INC.
SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORP.
NUMBER 7.40
PAGE 1 OF 9
CABLE MAKING

1 SCOPE

1.1 This standard shall govern the making of cables fabricated with the aid of a tool (board).

2 DEFINITIONS

2.1 Cable Assembly Wiring consists of conductors used to make connections between major units or sections of an exhibit (trainer). It may have a definite shape which will conform to the physical characteristics of the section or exhibit in which it is used.

2.2 Intra-Unit Wiring consists of dangling leads and/or completely self contained wiring which connects components, sub-assemblies

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ISSUED 8-29-55
REVISED 6-1-56
REVISED
SUBJECT
STANDARD DRAFTING PRACTICE
LINK AVIATION, INC.
SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORP.
NUMBER 15.4.1
PAGE 1 OF 6
COLOR CODE FOR CHASSIS WIRING

1 The wiring of electrical and electronic equipment shall conform to the following color codes and rules, the term "electronic" denoting vacuum tube or transistor circuitry as an integral part of a unit. The color shall be assigned leads on drawings as alphabetic or numeric designations. The alphabetic designations shall be enclosed in parentheses to avoid any confusion with functional designations. The basic color with its alphabetic or numeric designation is listed as follows:

Color	Alphabetic	~~Numeric~~	Color	Alphabetic	~~Numeric~~
Black	BLK	000	Green	GRN	555

ISSUED 4-11-56
REVISED
REVISED
SUBJECT
STANDARD SHOP PRACTICE
LINK AVIATION, INC.
SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORP.
NUMBER 6.23.
PAGE 1 OF 4
KNURLING

1. SCOPE

1.1 This standard establishes the Shop practices for knurling. It covers three (3) types of knurling; general purpose and precision straight knurling an diamond knurling.

1.2 General purpose straight knurling and diamond knurling are for grasping and decorative purposes on such items as knobs, shafts, handles and etc. The non-precision straight knurl has a large buildup and tolerance, therefore, it is not recommended for use in a press fit.

ISSUED 4-1-56
REVISED 4-1-57
REVISED
SUBJECT
STANDARD DESIGN PRACTICE
LINK AVIATION, INC.
SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORP.
NUMBER 10.3.4
PAGE 1 OF 1
COUNTERSINKING FOR FLATHEAD SCREWS WITH LOCKWASHER

SIZE OF SCREW	#2	#4	#6	#8	#10	1/4
DIAMETER OF SCREW	.086	.112	.138	.164	.190	.250
	.051	.067 .055	.083 .069	.100 .084	.116 .098	.153 .131

ISSUED 4-1-56
REVISED
REVISED
SUBJECT
STANDARD DESIGN PRACTICE
LINK AVIATION, INC.
SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORP.
NUMBER 11.11.
PAGE 1 OF 2
SURFACE ROUGHNESS

1 The degree of roughness of a finish on machined surfaces, castings and wrought stock shall be indicated by the symbols listed below.

Approximate Dimensions $\frac{3}{16}$ 60° 60° $\frac{3}{8}$

2 The surface roughness symbol (✓) embracing the surface roughness number represents the maximum acceptable roughness.

3 The degree of roughness of a finish on machined surfaces shall be governed by the tolerance on the dimensions. For example, if a machined diameter has a tolerance of .005, the roughness should be 125✓ or better. Finer finishes may be specified on special applications, e.g. polished film guides, knobs, etc.

4 The significance of the symbols is as follows:

Symbol	Quality	Max. RMS Value Micro Inches	Range of Total Tolerance	Typical Machine Operations	Design Applications
1000✓	Extremely Rough	1000	.063/.125	Flame Cutting	Sand Castings, Flame Cut Edges etc. where dimensional accuracy is unimportant.
500✓	Very Rough	500	.015/.063	Contour Sawing	Clearance Cuts, Blanking and Punching.
250✓	Rough	250	.010/.015	Snag, Saw Cut	Clearance Cuts and Surfaces on large parts where extreme accuracy is unimportant.
125✓	Semi-Smooth	125	.005/.010	Rough Turn, Shape, Mill, Bore & Drill	Accurate surfaces, milling, boring, and turning but not for sliding parts.
63✓	Smooth	63	.002/.005	Smooth Turn, Shape, Ream, Mill, Bore & Gear Teeth	Mating surfaces, housing bores for ball or roller bearing assemblies, broaching, but not for sliding surfaces.
32✓	Grind	32	.0005/.002	Grind or Finish Turn	Splined shafts, thrust face o a slide and reamed holes.
16✓	Grind	16	.0002/.0005	Grind, Hone or Burnish	Bearing bores and surface on shaft for precision work subject to vibration.

NUMBER 11.11.
PAGE 2 OF 2
SUBJECT
STANDARD DESIGN PRACTICE
LINK AVIATION, INC.
SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORP.
ISSUED 4-1-56
REVISED
REVISED
SURFACE ROUGHNESS

5 Surface Roughness Requirements

1000✓ Indicates that the surface is very rough and uneven within the dimensional requirements.

500✓ Indicates that the surface is rough and uneven within the dimensional requirements.

250✓ Indicates that the surface must be smooth and even to a degree obtainable by tools removing large chips or shavings. Machining marks and grooves discernible to the eye and to touch are permitted, if the surface meets dimensional requirements.

125✓ Indicates that the surface must be smooth and even to a degree obtainable by tools removing medium chips or shavings. Machining marks and grooves discernible to the eye are permitted, if the surface meets dimensional requirements.

63✓ Indicates that the surface must be smooth and even to a degree obtainable by tools removing small chips. Machining marks and grooves discernible to the eye are permitted, if the surface meets the dimensional requirements.

32✓ Indicates that the surface must be smooth and even to a degree obtainable by tools removing small particles. Machining marks such as grooves must not be discernible to the eye or touch, if the surface meets the dimensional requirements.

16✓ Indicates that the surface must be very smooth and even to a degree obtainable by tools removing very small particles. Machining marks such as grooves must not be discernible to the eye or touch, if the surface meets the dimensional requirements.

8✓ Indicates that the surface must be even to a degree obtainable by tools removing minute particles, generally by grinding. Machining marks such as the fine patterns resulting from grinding, must not be discernible to the eye or touch and the surface must have a polished appearance and meet dimensional requirements.

4✓ Indicates that the surface must be even to a degree obtainable by tools removing very minute particles, generally by honing, lapping or super finishing. Machining marks such as very fine patterns must not be discernible to the eye or touch and the surface must have a highly polished appearance and meet

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Company Standards

In the standards program developed at Link Aviation Inc., two types of standards are employed. One group consists of practices based on national and industry standards. Subjects covered are:

1. Welding
2. Surface Roughness
3. Unified and American Screw Threads
4. Precision and Clearance Fits
5. Spur Gears
6. Color Code for Chassis Wiring
7. Electronic Symbols
8. Abbreviations
9. Wire Specifications

The second group consists of standards developed to meet specific company product requirements. Subjects include:

1. Console Design
2. Aircraft Parts Modification
3. Fastening Devices
4. Cable and Harness Design
5. Countersinking for Flat-Head Screws
6. Periphery Dial Design
7. Layout of Components—Resistor Boards
8. Stripping of Wire
9. Sleeving
10. Shielded Wire Terminations

decision for specific situations should be based on a thorough analysis of all factors that may influence operation of the standards program.

Level of Organization

When a standards program is adopted, a key consideration is its level of operation in the company structure. If it is positioned low in the company table of organization, there is the problem of coping with departmental managers of a higher level who feel they cannot accept any of the standards for their operation. Result in such situations is either a set of standards for each department, or a standards manual that is not recognized by any department.

Greatest effectiveness is achieved when the standards program is responsible to a top executive of the company. Ideal approach is to make the program a staff function under an executive assistant or an executive vice president.

If properly administered, the standards program can be responsible to a divisional manager. In many companies, standardization is considered an engineering activity. On this basis, the program could be a staff function under the engineering division executive. But wherever the program is situated, it must be supported by top management.

Scope of Standards Program

One of the first steps in setting up a standards program is to determine how broad an area the program must cover. For technical standards, the important general subject categories for evaluation and action are:

1. Design Practices are concerned with the basic elements and procedures of design and their application to a product.
2. Drafting Practices define the elements of preparation of all types of drawings, bills of material, etc.
3. Manufacturing or Shop Practices define expected shop performance and may be used to supplement drawing information.
4. Manufacturing Processes define the processes that directly contribute to a finished part or assembly.
5. Part Standards define the preferred parts and components for reliable design. These elements are selected after careful review based on possible future repetitive use.
6. Material Standards define the materials to be utilized in the construction of manufactured products. These standards may also define the physical and chemical characteristics of the material.
7. Specifications consist of any specification prepared for the procurement of items, or for the control of critical construction details in subcontract jobs.

The standards program may contain all of these seven subject areas, separately or in combination, or it may include more or fewer items. The number will depend on the extent of standardization desired.

Of the seven subjects listed, the two most important areas are design and drafting practices which can be, and often are, combined and identified as engineering standards. These practices are an important part of any company standardization program. The drawings supplied by the engineering department constitute a major medium of communication between this group and the other departments of the company. The degree of conformity to standard practices in design operations, drawing preparation, and in the specification of materials and parts will determine the ease with which products are processed through fabrication stages and inspection procedures.

Benefits of a standards program do not always appear in tangible form. In areas such as design, drafting, manufacturing processes, etc., direct savings from standards are usually difficult to evaluate. An exception is parts standardization. Here, cost figures can be obtained without too much difficulty and savings directly determined. Quantity lots and competitive buying lead to savings. In addition, countless examples of substantial savings through parts standardization can be found in the literature.[1]

Operating Procedure

A standards program is only as strong as the support it receives from company management. Although management need not take an active part in the program, it should make known its endorsement of the operation. Such action is important to show that there is a desire for development and use of standards.

Management support of the standards program perhaps can be best expressed in the form of a managerial standard that defines the operating procedure for the standards program and has been approved and signed by a top company official, such as the president or general manager. If there is no formal managerial-standards procedure, the endorsement can be given by a general order or formal letter stating in broad terms top management's position on the standards program and anticipated accomplishments.

In content, the operating procedure for a standards program should spell out the scope of the program, its purpose, the responsibilities of the person designated to head up the program, and also the responsibilities of the personnel that are to staff it. Actual method of operation will be determined by company size, organization, and product. There are two basic modes of operation: 1. Committee. 2. Consultation.

In the committee method of operation, a definite committee is appointed for each subject area covered by the program. Each committee is made up of supervisory or managerial personnel of all departments affected by standards developed in this area. Meetings are called by the standards department or, in particular, by the standards engineer involved when a standard has been prepared and is ready for approval.

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[1] References are tabulated at end of article.

In the consultation type of operation, the standards engineer contacts key personnel directly and discusses the subject under consideration for standardization. Upon completion of a standard, each individual assigned to review the material is contacted for comments. These comments are then reviewed and evaluated by the standards engineer, who makes any necessary revisions to prepare the standard for final approval.

A third possibility is offered by combining these two basic methods of operation. In this approach, the consultation method may be used to prepare a standard which is then submitted to a standards committee for final approval. Another operational variation makes use of a standards committee for consideration of special programs or deeply involved subjects while minor routine jobs are handled by a standards engineer on a consultation basis.

Program Staffing

How a standards program is staffed depends upon the type of standards organization selected for company adaptation. Under the informal type of program, staff requirements are met by utilizing existing design, drafting, and manufacturing personnel as the occasion demands.

For the formal organization, selecting the personnel to staff the program becomes a more difficult problem. First, it is essential that one individual be assigned the responsibility of heading the company program. Ideally, the person selected should have a thorough grounding in standards fundamentals. However, if this qualification can not be met, the necessary background usually can be acquired through seminars conducted periodically on industrial standardization as well as through literature available from standards organizations.

Next consideration is the assignment of a standards engineer who will be responsible for compiling and preparing standards. Personnel selected for these positions should have a knack for writing and a knowlege of the particular subject area in which they will be working. Here again a standards background is advantageous but not absolutely necessary. Under trained supervision, an individual who is well-versed in a particular field can prepare standards in a clear, concise, and simple manner.

In addition, clerical help will be needed for typing, printing, and distributing revised or new standards, and for keeping files and records.

The number of standards engineers and clerical personnel will, of course, depend upon the size and type of program planned. Experience has shown that it is best to begin with a small standards organization and build as the program progresses.

Sources of Information

A wealth of standards information on a wide range of subjects is currently available in published form. Much of this material is national, or international, in scope, providing a practical basis for communication among engineers on common problems.

In the development of a company standards program, priority should be given to the use of "national" standards wherever possible. Often, the standards can be used without changes, although modification may be necessary to satisfy requirements of established company practices and facilities. If modification is required, definitions and usage of terms should be maintained to assure understanding.

A number of technical societies are engaged in standardization work on a national scale. Representative groups from which copies of national standards can be obtained are listed in Sources of Standards.

The American Standards Association is generally recognized as the national standards body in this country. It also represents this country in the International Standards Organization (ISO). In practice, the ASA functions primarily as a standards clearinghouse. All of the standards published by this group are sponsored and developed by national professional societies, trade associations, and consumer organizations.

Another important source of standards information, particularly where military contracts are involved, is government specifications and standards. A guide to such specifications, including a listing of sources for copies of the publications, has been presented in an earlier article.[2]

Other good sources of material are companies which have active standards programs. Many of the standards departments in these companies will supply a set of their standards on request.

In addition to these information sources, the standards engineer has an important ally in the Standards Engineering Society (P.O. Box 281, Camden 1, N. J.). This national group, with local sections throughout the country, was formed to aid and promote the cause of standardization. Development or issuance of standards on specific subjects is excluded from its activities. It serves primarily as a "meeting ground" for exchange of information among standards engineers on common problems and professional aspects of standardization.

REFERENCES

1. *Dollar Savings Through Standards*, American Standards Association, New York.

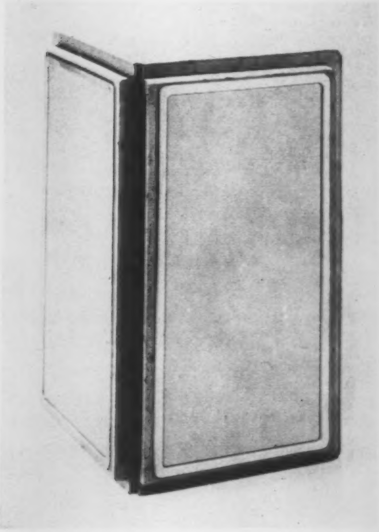
2. M. Barov—"Government Specifications," MACHINE DESIGN, Vol. 29, No. 3, February 7, 1957, pp. 76-80.

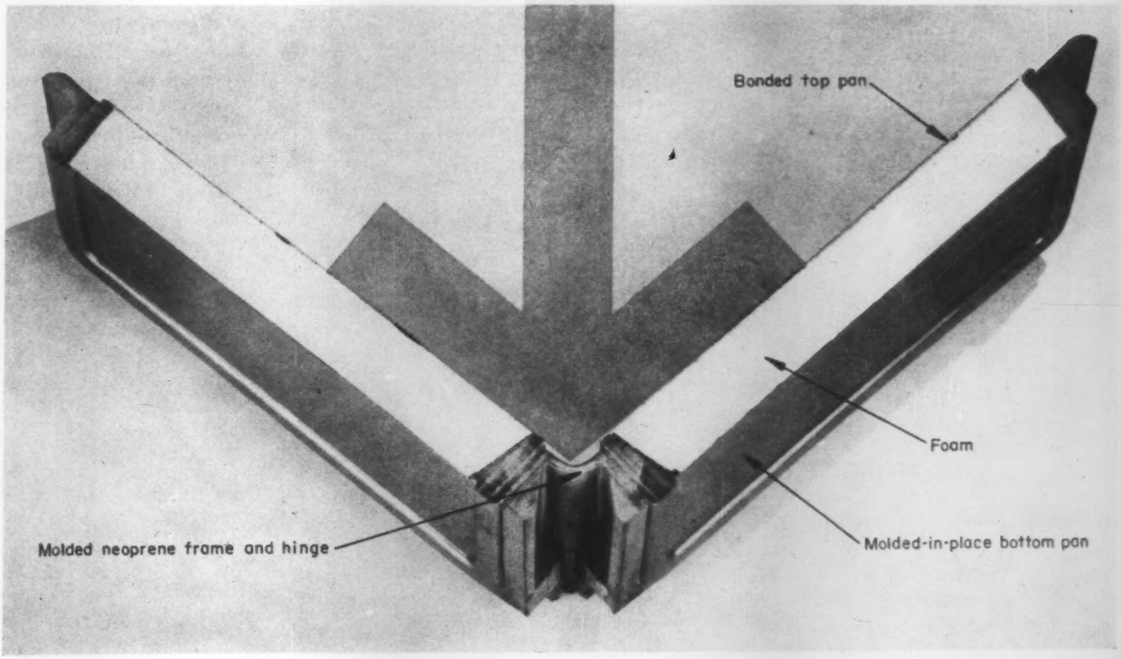
They Say . . .

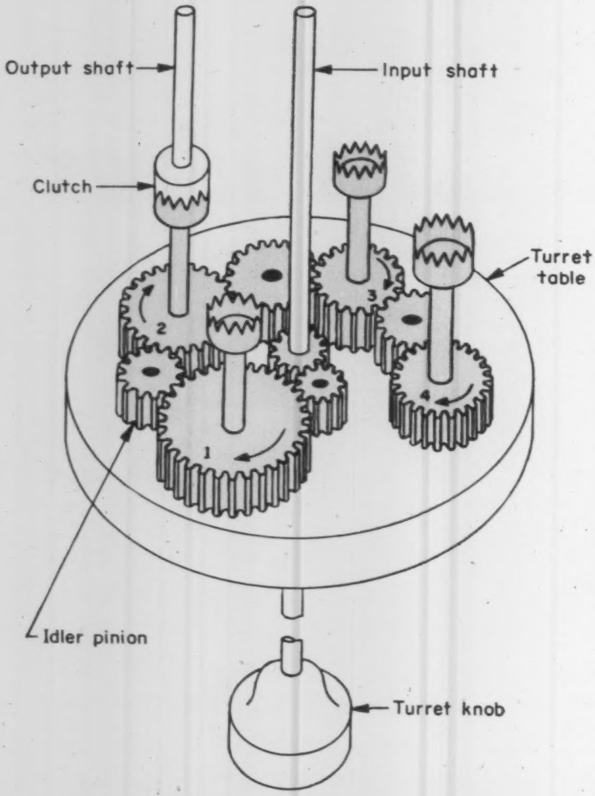
"There was a wartime motto displayed in many offices to the effect that 'the difficult we do immediately, the impossible will take a little longer.' We need to take a more realistic, and more modest, view of our ability to the end that our achievements—and their contribution to our security and welfare—will be even greater in the future."—MORROUGH P. O'BRIEN, *dean, College of Engineering, University of California, Berkeley, Cailf.*

scanning the field for *ideas*

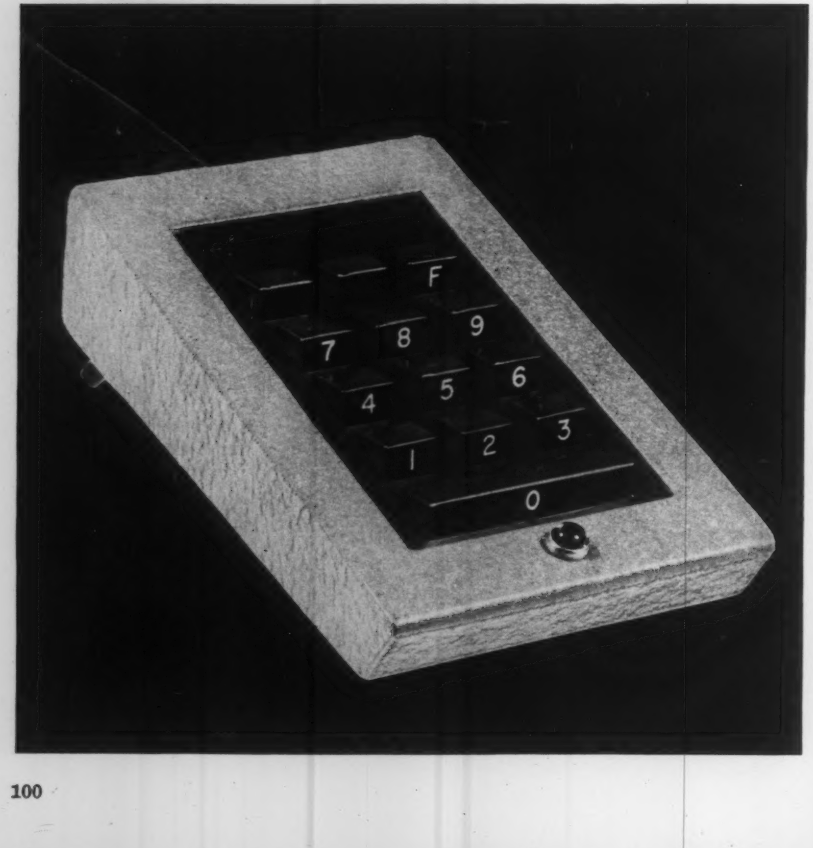
Foamed-plastic "fastening" offers a neat and effective assembly technique without conventional hardware or joining methods. Reported by Benjamin Collins, Nopco Chemical Co., foamed plastic is employed to fill the void within a hollow door and to bond the door frame and panels into a rigid assembly. The door frame is molded neoprene, with the steel bottom door-panel embedded into the frame during molding. The frame is then filled with liquid foamed plastic and the top pan is clamped in place. As the foam expands, it completely fills the void in the door and forms a tight bond to the steel and the neoprene to tie the assembly together.




Bonded top pan
Foam
Molded neoprene frame and hinge
Molded-in-place bottom pan



Selective speed control is obtained in a transmission design by rotary indexing of a circular gear-train arrangement. Mounted on an indexable table, the multiple-gear train has several "output" gears, proportioned to provide varying speed reductions, and connected by idlers to maintain direction of rotation. Each output gear has a stub shaft and a toothed-clutch element. For each position of the turret table, the clutch on one of the output gears is engaged with the output shaft. To change speeds, the turret table is moved away from the output shaft to disengage the clutch. The table is then indexed to bring the desired gear into alignment with the output shaft and the clutch is re-engaged. The design was developed by Insco Co., Div. of Barry Controls Inc.



Face-display of numerals offers possibilities in the design of operator keyboards where wear or visibility of conventional top markings is a problem. In a keyboard developed by ElectroData Div. of Burroughs Corp., the numerals are located on the front side of the keys, rather than on the top. The novel location avoids dimming or removal of the markings due to wear during use.

By **CARTER C. HIGGINS**
President and General Manager
Worcester Pressed Steel Co.
Worcester, Mass.

PART 1
FLAT
STAMPINGS

PART 2
FORMED
STAMPINGS

A practical manual for

Stamping Design

STAMPINGS can be as small as the eyelet in a shoe or as large as the end of a freight car or the 20-ft long frame of an automobile. One firm is warm drawing 15/16-in. silicon-steel tank heads up to 10½ ft in diameter and 35 in. deep. Small stampings are usually considered as being up to about 3 in. in largest dimension; medium stampings from 3 to 11 in. (or somewhat longer for channel shapes); and large stampings from there to an auto roof. The first are often formed on presses powered by kicking; medium stampings are made on 50 to 150-ton presses; and large stampings require large press beds, strokes up to 6 ft long to get a 3-ft deep part, and pressures as high as 8000 tons.

Economical Quantities: There is no upper limit to stamping production—it meets mass-production needs. Small stampings may be made at over 18,000 strokes an hour, and as many as a dozen stampings per stroke. Large stampings requiring several operations with intermediate anneals are much slower, running down to 100 an hour.

Inherent in the stamping process is the comparatively high cost of conventional tools and setups for low-quantity production runs. A large, complicated aluminum helicopter part was made as a stamping to avoid a great deal of machining if made as a forging and tools were paid for on a run of 6 pieces—but this was very unusual. However, a request to quote on one or two thousand large stampings costing over a dollar apiece will usually bring quotations.

A stamper faced with a small order must enter

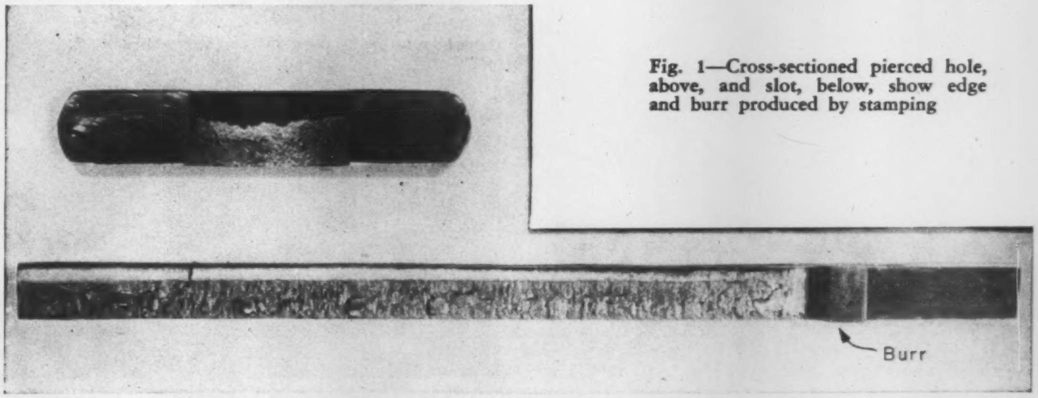


Fig. 1—Cross-sectioned pierced hole, above, and slot, below, show edge and burr produced by stamping

it on his books, order materials, and set up dies in his presses, the same as with a large order. In addition, he pays high material-quantity extras. Setting up to run 500 medium parts costs as much as the actual production; 1000 can often be bought at a third less cost per unit (plus material, of course). The difference in unit cost between 15,000 and 25,000, however, is minor in most cases. For shorter runs of small and medium-size stampings, special methods and tooling are employed.

▶ Material for Stampings

Any material softer than tool steel and which will not shatter with impact may be blanked. For drawing, the prime requirements are reasonable elongation and a spread between yield strength, where the stock takes a permanent set, and rupture strength where it breaks. Stampers use more low-carbon steels than all other materials combined. These steels, usually in the annealed state, are regarded as "standard," as opposed to "soft materials" like lead, aluminum, or copper, and "stiff" materials like medium-carbon steels and alloys, stainless, or half-hard tempered materials. In this article, when limitations are mentioned, mild steel is the material assumed.

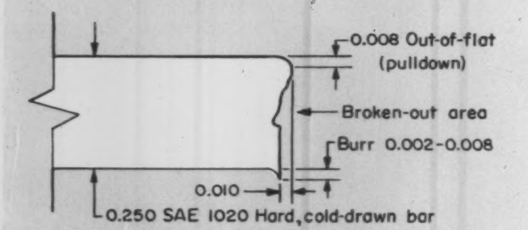
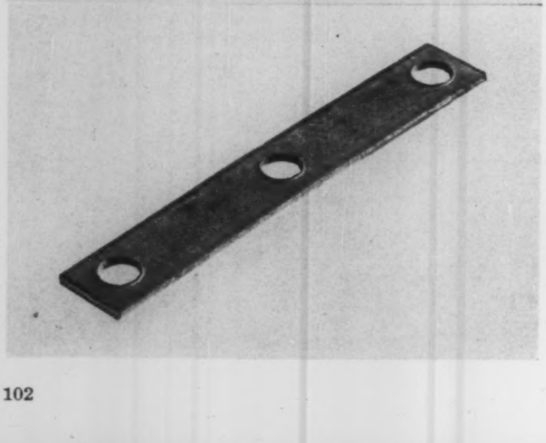


Fig. 2—Heavy stock blanks with a double shear, producing burnished area near each side of the edge

Fig. 3—Lack of specification for maximum burr allows stamper to get maximum runs between sharpenings. Parts can be tumbled to remove sharp edge of burr



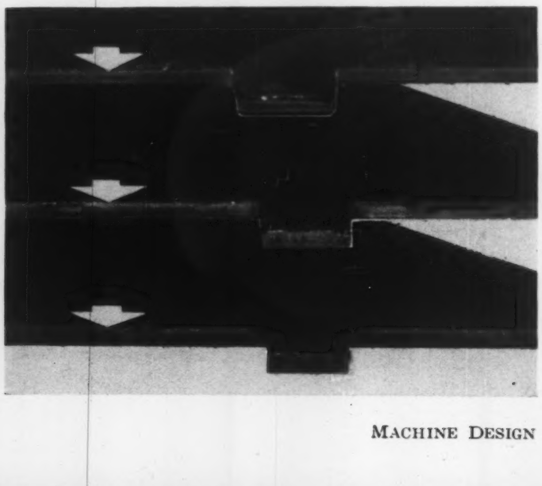
Materials regularly used by stampers, in increasing order of cost, are: hot-rolled plate, bar, sheet, and strip steel with 5 to 25 points of carbon, lighter hot-rolled and cold-rolled sheet and strip steel, medium-carbon steels and low alloys employed for strength and corrosion resistance, lead (tears easily), ingot iron, zinc (which has good properties although seldom considered for stampings), medium-alloy steels, aluminum, magnesium, chromium-stainless steel, brass, copper, nickel-bearing stainless, phosphor bronze, Monel, cupronickel, nickel silver, Inconel, zirconium, titanium, molybdenum, silver, gold, and platinum. Usual material thickness runs from 0.004 in. to about 0.625 in.

Specialty Materials: Precoated materials are becoming more popular; to consider coated steel in order of cost, there are terne plate, lithographed stock, tin plate, galvanized, copper-plated or copper-clad, vinyl-plastic coated, cadmium, chrome, and nickel-plated, and stainless-clad steels. Other clad metals are Alclad, used for corrosion resistance, and alcuplate (copper on aluminum) used for soldering or heat transfer. Generally, rough hot-rolled materials take paint very well, but the commercial bright cold-rolled materials are superior for polishing and plating. Special brass is available for forming and plating, and there are also polished grades of cold-rolled steel and stainless. These lustrous materials require very special handling even for simple shapes and are poor materials for drawing.

Aluminum-killed steel in soft temper (which means a temper pass through the rolls after anneal) is used because it does not age harden during storage. Also, the grains do not separate to produce stretcher-strains when it is deep drawn or stretched into complex shapes. Among the stronger materials frequently stamped are medium-carbon steels such as AISI 1035 to 1070, SAE 4130 plain or stabilized, stainless steels, and titanium alloys such as 6 per cent aluminum, 4 per cent vanadium.

Changes in Strength and Hardness: Strength in-

Fig. 4—Fin blanks of SAE 4130 steel are shaved to improve edge smoothness and precision. Edges, from top to bottom, are blanked, one shave, and two shaves.



creases greatly as material is work-hardened by drawing. Hard, cold-rolled steel is twice as strong as soft steel. Drawn parts can be made to a minimum Rockwell hardness by spacing the anneals. Of course, the hardness is greatest in those portions of the stamping where the material is most worked. Steel with 15 or 20 points of carbon, though not heat treatable, is rather harder than the more usual 8 to 10-point carbon steels, but the principal use for these higher-carbon steels (aside from clutch and gear plates) is for future carburizing. The harder metals will take less draw and call for larger radii than mild steel.

Gages and Tolerances: It is well to use standard-gage steels to take advantage of warehouse inventories or to combine with other orders for price advantages. Gages usually available are: 0.015 in., 0.020, 0.025, 0.031, 0.035, 0.042, 0.050, 0.062, 0.072, 0.093, 0.109, 0.125, 0.145, 0.156, 0.171, 0.187, 0.250, 0.312, 0.375 and 0.500 in. Standard sheets are usually 36 or 48 in. wide. Stock is usually considered light-gage up to 0.031 in., medium from there to 0.109, and heavy from 0.125 in. up. Material thickness should always be specified in decimals rather than in gages.

The trend is for cold-rolled steel to invade heavier gages than formerly, partly because hot-rolled, normalized steel for drawing is almost impossible to obtain. Commercial hot-rolled steel runs quite hard (and variable) for small-radius bends and shallow draws, but is less expensive than cold-rolled steel over 0.050 in. thick. Soft, cold-rolled steel costs less than hot-rolled, annealed, pickled, and oiled (H.R.P.O.) up to 0.0635, and for the most severe working, is economical up to 0.071 in. Cold rolled is held to closer tolerances than hot rolled and is smoother.

Bar, plate, strip, and sheet refer to combinations of thickness and width; both strip and sheet can be purchased as coils, Table 1. Strip is rolled to closer tolerances than sheet, but plan on sheet tolerances where possible, since it costs a cent or two a pound less. For strip steel, there is a plus crown tolerance as well as the gage tolerance. Closer-than-commercial tolerances are obtainable, down to about a third of the commercial spread, at extra cost. Most narrow material is slit from sheet up to thicknesses that are hard to feed in uncoiling setups—0.093 to 0.109 in., depending on width. Narrow cold-rolled steel over 0.250 in. thick is called cold-drawn bar and costs 14 to 20 cents per pound. This may be used to avoid grinding.

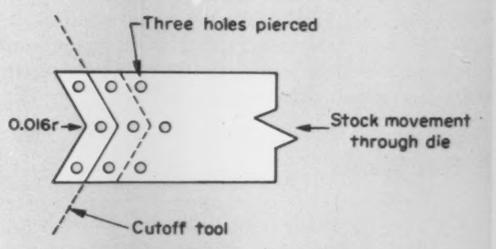


Fig. 5—Careful part design can reduce scrap to only the material pierced from holes

Specification of Material: Although the simple call for "steel" gives the stamper some leeway between AISI 1008, 1010, and 1012 (all mild steels), a call for "brass" or "stainless steel" can be confusing. Yellow brass (70-30) and cartridge brass (75-25) are more than 3 cents per pound cheaper than red brass (85-15), and would usually be assumed. Type 430 stainless steel is 56½ cents a pound cheaper than type 310, and 9 cents cheaper than type 202. In order of cost, stainless steels

Table 1—Classification of Hot-Rolled Steel

Width (in.)	Thickness up to 0.0141 in.	0.0142 to 0.0254	0.0255 to 0.0343	0.0344 to 0.0448	0.0449 to 0.0567	0.0568 to 0.1799	0.1800 to 0.2030	0.2031 to 0.2299	Thickness over 0.2300 in.
To 3½	Sheet*	Sheet*	Strip	Strip	Strip	Strip	Strip	Bar	Bar
3½ to 6	Sheet*	Sheet*	Sheet*	Strip	Strip	Strip	Strip	Bar	Bar
6 to 12	Sheet*	Sheet*	Sheet*	Sheet*	Sheet	Strip	Strip	Strip	Plate
12 to 32		Sheet*	Sheet*	Sheet*	Sheet	Sheet	Sheet	Sheet	Plate
32 to 48	Sheet*	Sheet*	Sheet*	Sheet*	Sheet	Sheet	Sheet	Sheet	Plate
Over 48	Sheet*	Sheet*	Sheet*	Sheet*	Sheet	Sheet	Plate	Plate	Plate

*Hot-rolled annealed

Classification of Cold Rolled Steel

Width (in.)	Thickness up to 0.0141 in.	Thickness 0.0142 to 2.2499	Thickness over 0.2500 in.
½ to 12	Strip	Strip	Bar
12 to 24[1]	Strip	Strip	Strip
12 to 24[2]	Black plate	Sheet	Sheet
24 to 32	Tin-mill or black plate	Sheet	Sheet
Over 32	Sheet	Sheet	Sheet

[1] When a particular temper or a special edge or finish is specified.

[2] When no special temper, edge, or finish is specified.

used by stampers are (low to high): Type 410, 430, 202, 302, 304, 305 (extra-deep draw), 316, 321, 347 and 310 (high heat). Oddly, on stainless steel, strip rolled less than 24 in. wide costs less than the wider sheet products.

▶ Flat Blanks

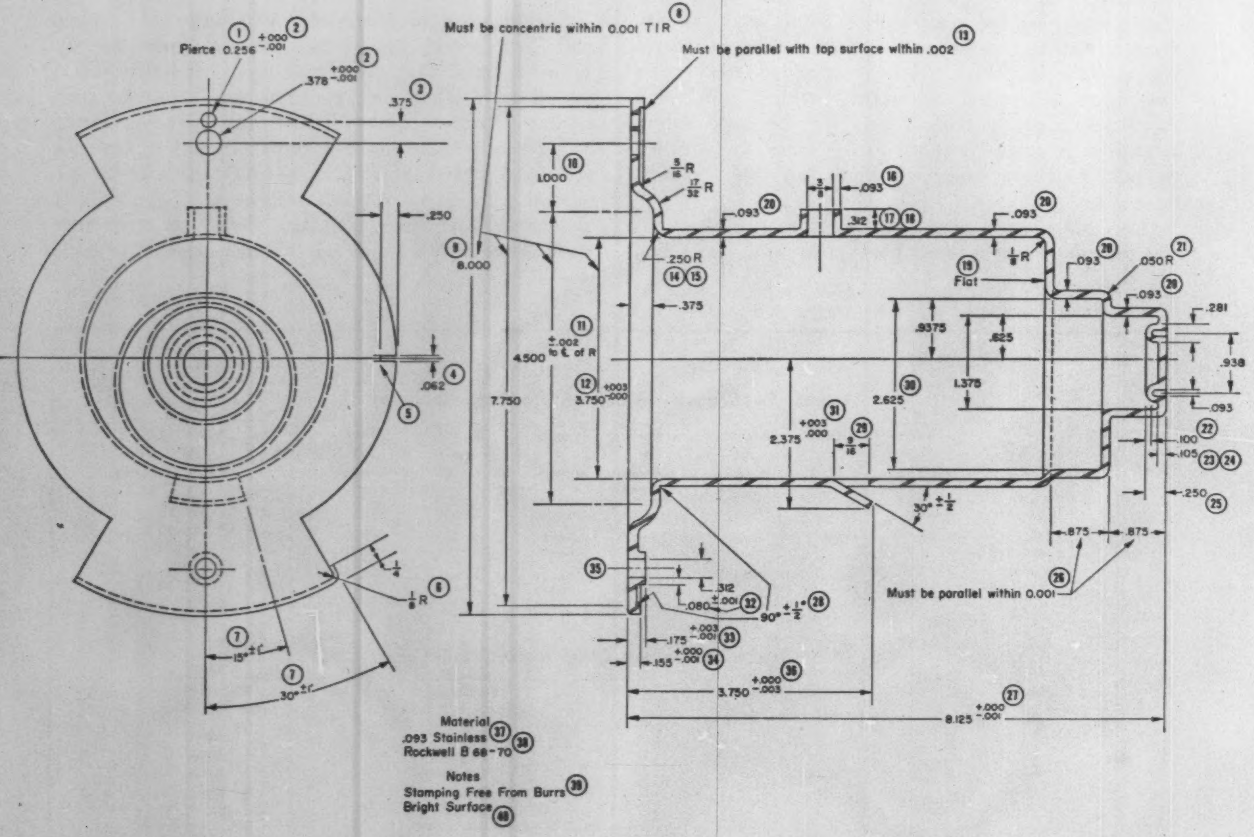
Flat stampings include stampings of varying outlines and thicknesses, blanked, sheared, cut off, pierced, or shaved. There are washers, cam blanks, shims, laminations, perforated sheets, cover plates, and many kinds of link arms. These shapes may be stacked and brazed, welded, or riveted to build up items such as a padlock body with interior passages or a fairly heavy gear. With 8-cent steel and another 8 cents for cut-off and assembly, a price of 16 cents per pound compares favorable with other materials.

Flatness: Despite apparent simplicity, there are problems with flat stampings. One is the problem of flatness itself. Mills ask for ±0.500 in. out-of-flat for a 120-in. sheet. Stretcher-leveling provides steel that is flat within ±0.062 in. If a mill edge is ordered on sheet over 12 in. wide, the stock comes flatter than regular sheet at no extra in price —in fact a bit less.

Striking a piece between two flat surfaces to impart flatness is not very satisfactory due to springback. If a tool is developed with the proper amount of overbending to give a good result, the next lot of steel has different characteristics.

The specification "must be flat" is an invitation to argument. A tolerance as wide as possible should be permitted, up to ±0.015 in. on medium-size parts although a smaller area like a cup flange can be held closer. The alternative is grinding—or a man sitting at a bench with a hand or air hammer, pounding away and checking with a straightedge—a 20-an-hour sort of thing. If a 0.004 to 0.008-in. tolerance spread is necessary, the stamper must resort to grinding. Some materials, particularly brass, have a tendency to warp during storage.

"Commercially flat" calls for no special operations, but does influence tool planning and mate-



① Pierce 0.256 +.000 −.001 ②
.378 +.000 −.001 ②
.375 ③
.250
.062 ④
⑤
¼
⅛ R ⑥
⑦ 15° ±1°
⑦ 30° ±1°
Must be concentric within 0.001 TIR ⑧
⑨ 8.000
1.000 ⑩
⑪ ±.002 to ℄ of R
4.500
7.750
⑫ 3.750 +.003 −.000
Must be parallel with top surface within .002 ⑬
5/16 R
17/32 R
.250 R ⑭⑮
.375
3/8
.093 ⑯
.312 ⑰⑱
.093 ⑳
⑲ Flat
⅛ R
.050 R ㉑
.281
.938
.093
.100 ㉒
.105 ㉓㉔
.250 ㉕
.9375
.625
1.375
2.625 ㉚
2.375 +.003 .000 ㉛
9/16 ㉙
30° ±½
.875
.875
Must be parallel within 0.001 ㉖
㉟
.312
.080 ±.001 ㉜
90° ±½° ㉘
.175 +.003 −.001 ㉝
.155 +.000 −.001 ㉞
3.750 +.000 −.003 ㊱
8.125 +.000 −.001 ㉗
Material ㊲
.093 Stainless
Rockwell B 68-70 ㊳
Notes
Stamping Free From Burrs ㊴
Bright Surface ㊵

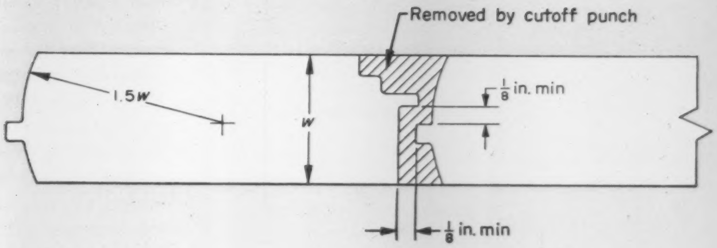


Fig. 6—If parts have two opposite straight edges, they can be produced by a cutoff operation even if the other two sides do not mesh

rial handling. Blanking or piercing heavy stock results in a pulldown around the edge and around the holes. This is not considered when checking an over-all flatness specification. The pulldown can be reduced by shaving, but costly grinding or machining is the only effective way to eliminate it.

Another way to get good flatness is to use more than one layer of thin material because it will take the shape of the surface it rests on. Three layers of light material will cost more per pound than one piece three times as thick, but may cost less than flattening.

Edge Conditions: Depending on the temper, the punch enters for 25 to 50 per cent of stock thickness; the metal breaks the rest of the way, Fig. 1. Die clearance is about 10 per cent of material thickness. On heavy stock, a double break sometimes occurs. This leaves a burnished area on both punch and die sides of the stock and broken material between, Fig. 2. On hard, heavy stock, the die side of the

Drawing of a stamped part. This drawing, devised by Fred C. Valentin, Manufacturing Engineer, Worcester Pressed Steel, represents the culmination of considerable research into the causes of gray hair among stampers. All told, the drawing contains 40 specifications that are impractical, impossible, or meaningless.

1. **Nonstandard punch sizes add expense.**
2. **Tolerance does not permit punch wear.**
3. **Holes are too close together. They should be joined or each will require reaming and deburring.**
4. **A 1/16-in. wide punch will not stand up in 0.093-in. thick stainless.**
5. **Without relief notches, the tab will tear at the base corners.**
6. **A flange extending around such a sharp corner will crack.**
7. **Angular tolerance cannot be maintained.**
8. **Tolerance is much too tight and very difficult to check.**
9. **Derived thickness is 0.125 in., which cannot be obtained from 0.093-in. material.**
10. **Hole is located from a point that cannot be measured.**
11. **Tolerance on a dimension which cannot be gaged.**
12. **Tolerance is much too small for a 6-in. deep cup, although it might be held for a short distance.**
13. **Flange will not be this flat, so edge cannot be held parallel to it.**
14. **Outside radius should be dimensioned as inside radius plus stock thickness.**
15. **Radius given cannot be met if inside corner is sharp.**
16. **Wall thickness of an extruded-flange hole thins remarkably.**
17. **Not enough material in hole to provide required flange height.**
18. **Height cannot be held to this tolerance, particularly when its base is on a cylindrical surface.**
19. **Designation "flat" or "must be flat" is meaningless. How flat is "flat"?**
20. **Drawn cup will not have uniform wall thickness at all these points.**
21. **Radius is less than stock thickness in a place where it is difficult to coin or upset.**
22. **Stock will thin, rather than thicken, at the bottom of a rib.**
23. **Impossible to secure a heavy bottom on a step-drawn cup.**
24. **Stainless does not iron well enough to produce this thickness, even on a straight-wall cup.**
25. **Depth requires excessive stretching of stock in relation to original area.**
26. **Tolerance is much too tight—would require machining.**
27. **Impossible tolerance since neither surface will be this flat.**
28. **Angular dimensioning implies a sharper corner than can be obtained and makes inadequate allowance for springback on short flange.**
29. **Insufficient material in hole to form tab shown.**
30. **Off-center, deep draws are almost impossible to produce.**
31. **Due to springback, tab cannot be held to this tolerance.**
32. **Even when ironed, wall of an extruded-flange hole thins at the end and cannot be held this close for its entire length.**
33. **Length of extrusion cannot be held this close and would require machining.**
34. **Flange should be at least 0.290 in. high. Dimension given requires trimming.**
35. **Location of extruded hole makes trimming flange almost impossible.**
36. **End of lance-formed tab distorts and cannot be held to close tolerances without machining.**
37. **Many materials are called "stainless." Stamper will probably use least expensive one available.**
38. **Range is too narrow and does not reflect changes as material work hardens.**
39. **Does not indicate whether all burrs are to be removed, what extra costs and operations are anticipated, or what the designer considers as a "burr."**
40. **Stainless-steel parts, after annealing for processing during drawing, rarely come out bright. If the surface has a powdery cloudiness or is darkened, this note might call for polishing which would affect tolerances.**

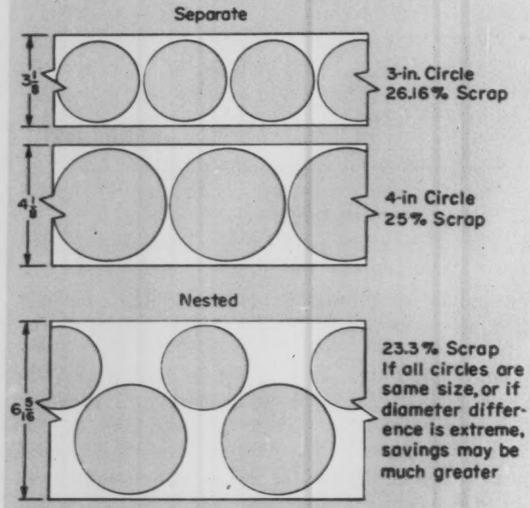

Separate
$3\frac{1}{8}$
3-in. Circle 26.16% Scrap
$4\frac{1}{8}$
4-in Circle 25% Scrap
Nested
$6\frac{5}{16}$
23.3% Scrap If all circles are same size, or if diameter difference is extreme, savings may be much greater

Fig. 7—Nesting shapes can result in substantial tool and labor savings if pairs are always required

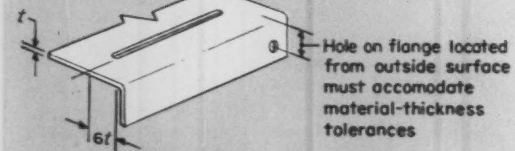

t
Hole on flange located from outside surface must accomodate material-thickness tolerances
6t

Fig. 8—Slots parallel to a bend should be at least 6*t* away from start of bend radius

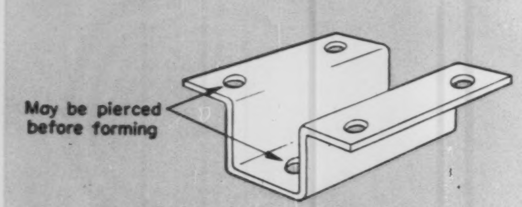

May be pierced before forming

Fig. 9—Only holes on unworked surfaces can be pierced prior to forming

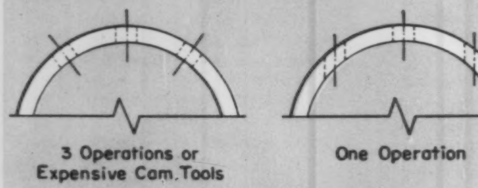

3 Operations or Expensive Cam.Tools
One Operation

Fig. 10—Radial holes are expensive and should be avoided if parallel holes will fulfill requirements

blank tends to be a little smaller than the punch side, despite die clearance.

Burrs: The piece that moves ahead of the punch, in blanking, piercing, or trimming, receives a burr on the punch side. The other piece receives a pull-down on the punch side and a burr on the die side. With proper clearance, this burr should not extend more than 0.003 to 0.004 in.—a note "No unreasonable burrs" signifies this. As tools wear, the burrs increase until tools are resharpened, Fig. 3.

Burrs can cause trouble in assembly, people can cut fingers on them, and a burr that spalls off into an oil system can play havoc. Designation of one side of the part as the burr side is frequently helpful. Sometimes holes can be countersunk lightly on the burr (die) side. Hard-temper stock reduces burrs. Small and medium-size parts, heavy enough not to distort and where finish is not vital, can be rattled together to knock the burrs flat—an inexpensive process. Sometimes in a succeeding operation a burred edge can be hit and the burr flattened at little or no cost. For most parts, a note to "Remove all burrs and sharp edges" calls for tumbling, which is quite effective and costs about the same as another press operation. The same note on a thin or large part calls for hand removal of burrs by grinding or filing. This is expensive and uncertain because of the human element. Particularly when a part has to be hand deburred, limiting burr removal to critical edges designated on the print will save money.

Edge-Improvement Methods: The sheared edge may be unsatisfactory, especially on heavy stock. These are not good bearing surfaces and they are not straight. A shaving operation may be specified which takes off a few thousandths of metal, improves straightness, brings closer tolerances, and improves finish to the equivalent of rough machining. On very heavy stock, the break may be deeper than one shave, and two, or even three shaves may be required, Fig. 4. Surfaces to be shaved should be designated on the print. Extensive abrasive tumbling will also improve roughness of the edge.

Material Economy: The shape of the stamping should be laid out for greatest material economy to reduce scrap and to avoid very narrow stock which costs more per pound than wider material. When great precision is not required between parallel straight sides or ends (±0.005 to ±0.008 on 6-in. width, or ±0.015 on 6 to 24-in. width), a shape may be cut off from strip with no scrap except for holes and notches, Fig. 5. Away from the edge of the material the shape may be fairly complex. One case where narrower material is used is to take advantage of mill edge material in a cut-off operation. This stock has a smooth edge but is not too accurate. For example, ±0.031 in. on 1 x 0.078-in. stock is a usual width tolerance.

Design Suggestions: Cut-off tools may be made to cut out a notch over $\frac{1}{8}$-in. wide, on light and medium stock. Also, any rounded shape or a right or obtuse-angle bend can be put on across the stock. Blanks will have scrap on two sides, and be scrapless on two—the shapes do not have to mesh, Fig. 6. This is particularly helpful when using expensive material since scrap is usually worth less than 25 per cent of new-material cost.

In contrast to blanking tools, cut-off tools can go out to edges of stock at acute angles. However, round blanks cannot be cut off because a feather edge on the scrap will be produced at the blank's largest dimension, register is difficult and die wear is abnormal. To cut off a part with flat sides and rounded ends, the end radius should be well over half the stock width. In common with blanking, interior shapes should be rounded. Although possible, acute angles are particularly troublesome because the sharp points of heat-treated punches tend to flake off.

Most stampings are blanked all around for greater precision. Here the radius of a rounded end, or projection, can be half the part width, and the die can be made easily. Avoid acute angles between sides and edges if possible. Nesting blanks will achieve material savings. When it does not pay to build double tools, stock is frequently run through the press twice to nest together shapes like T's or round blanks, Fig. 7.

Much material could be saved if the stamper knew that the same quantity of two different shaped parts would always be ordered so it would be acceptable to nest and blank them together. A double blanking die saves the labor on one part and may save material as well. Lamination dies are frequently doubled with the scrap from one part furnishing material for the second since rings with large holes are very wasteful of material. Unless the print so indicates, there is always the fear that some day more of one part will be needed than of the other, and separate tools are built.

Blanking Tolerances: Blank sizes and tolerances are determined by the dies. Since clearance varies with stock thickness, tolerances are larger for heavy than for light stock. Also affecting tolerances are die wear and complexity of shape. For blanks and holes, workable tolerances are given in Table 2. These tolerances can often be reduced by about 20 per cent at an additional cost of tool repairs, or by 75 per cent by reaming or shaving.

▶ Holes and Slots

Like notches in blanks, hole diameters should not be less than 0.5*t*. With stiffer materials, they should be 0.8*t*. The old rule of holes not less than *t* in diameter is no longer true and is constantly violated. However, to avoid frequent replacement of little punches, avoid holes under 1/32 in. Standard punches are available in increments of 1/64 in. and are much cheaper than special punches. They are also available for square, rectangular and oblong holes. Most round holes can be located quite accurately on a plane: ±0.002 in. between holes is not uncommon. Groups of holes located from formed edges, center lines, or ribs, are commonly located within ±0.004 in.

Slots are best located by their centers, particularly if several of the same size are involved. If located from each other rather than a base point, avoid the effects of accumulated tolerances. Oblong slots with rounded ends are somewhat more economical than square ends unless standard rectangular or square punches are available.

All holes are pierced in the same stroke wherever possible. This suggests that two holes should not be closer together than 0.050 in. on light stock and 0.125 in. on heavy stock. Otherwise, the die wall between them is too delicate. Stiff materials call for larger spacings. Piercing is also combined with notching and trimming for economy, so holes should not be too close to edges—0.050 to 0.125 in., and never less than *t*. Avoid holes so close together that even when pierced separately, they will distort each other and have to be reamed. A hole should be at least 3*t* from the start of a bend radius, and a long thin slot, 6*t* away or pierced after the bend, Fig. 8.

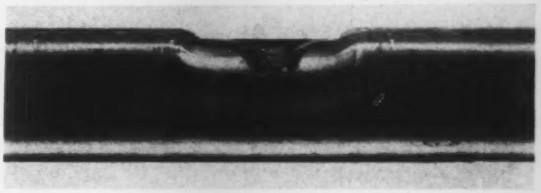
It is almost always cheaper to pierce holes in the flat, before forming. Holes on a bent-up tab or wall are located from the top of the original plane; if the designer dimensions from the under surface of the original plane, material tolerance will affect accuracy of the hole locations, Fig. 8. Center of a hole on a tab or wall can be located within ±0.005 in. as far as 2 in. from the original plane. Closer tolerances require secondary piercing.

Accurate holes cannot be pierced before drawing operations, except on surfaces that will not be worked, such as flanges or the bottom of channels, Fig. 9.

Table 2—Pierced-Hole Tolerances

Stock Thickness	Hole Diameter	Practical Tolerance
Light	Up to 1 in.	±0.003 in.
	1 to 10	±0.005
	10 to 20	±0.010
Medium	Up to 1	±0.006
	1 to 10	±0.012
	10 to 20	±0.020
Heavy	Up to 1	±0.015
	1 to 10	±0.025
	10 to 20	±0.035

Fig. 11—Cross-section of an extruded hole prior to tapping, designed to permit increase in thread length



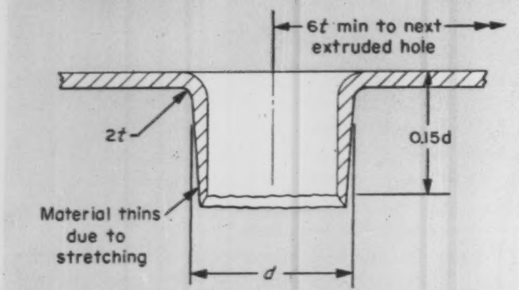

6t min to next extruded hole
2t
0.15d
Material thins due to stretching
d

Fig. 12—Design parameters for extruded holes

If there are several holes on a radial or complex surface, they may all be pierced by a single press motion. If quantities are quite large and holes are well separated, the stamper may devise wedge, or cam tools so that punches approach from several directions, Fig. 10. However, this means a big press.

Extruded Holes: Holes and notches with extruded flanges around them are useful for bearing surfaces, for tapping to avoid adding fittings, Fig. 11, or to hold locating pins. They may permit substantial reductions in material thickness by causing a thin cover to look heavier or to avoid sharp edges.

The basic operation is to pierce the hole and then to draw its periphery. The circumference of the hole is drawn out to the diameter desired, involving quite severe stretching. A rule of thumb for the height of the extrusion is 15 per cent of final extrusion outside diameter, Fig. 12. On medium or heavy-thickness, ductile material, the flange length can be extended to 25 to 30 per cent of hole diameter by using an oversize extruding punch and combining an ironing action with the normal thinning. There should be $6t$ between holes, and $4t$ to an edge.

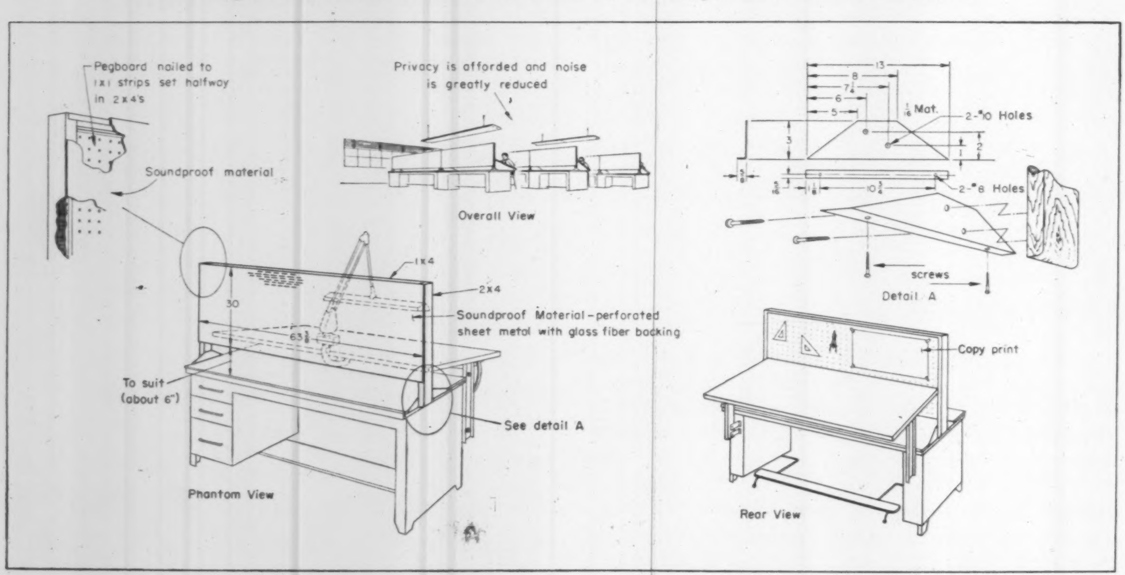
Small-diameter holes, up to about 1/16 in., are pierced and drawn down simultaneously; the extrusion end comes out rather ragged. Up to ¼ in., a sharp-edged punch is used, giving a smoother edge.

The ID of an extruded-flange hole is smooth and accurate within 0.003 or 0.004 in. but the OD thins toward the bottom. If a sharp radius, approaching t, is called for, less metal can be drawn in and the wall has to come almost entirely from the hole, meaning less depth and thickness. A $2t$ radius gives a thicker flange—or, if ironed, a deeper flange. If constant flange thickness is indicated by dimensioning both ID and OD, material must be gathered in a drawn boss before piercing. This involves additional cost. If wanted, indicate on print or stamper will assume that thinning is not objectionable.

The second part of this article will cover the design aspects of formed parts, strengthening means, deep-drawn parts, and alterations of thickness.

Tips and Techniques

Drafting-Board Divider for Convenience, Privacy, and Noise Reduction


Pegboard nailed to 1x1 strips set halfway in 2x4's
Soundproof material
Privacy is afforded and noise is greatly reduced
Overall View
1x4
2x4
30
63⅜
Soundproof Material–perforated sheet metal with glass fiber backing
To suit (about 6")
See detail A
Phantom View
13
8
7¼
6
5
1/16 Mat.
2-#10 Holes
3
2
1
5/8
5/16
1⅛
10¾
2-#8 Holes
screws
Detail A
Copy print
Rear View

—D. G. Zimmer, *International Business Machine Corp., Owego, N. Y.*

Human-Factors Engineering—6

Data and Design

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IMPORTANCE of the man-machine system concept in human-factors engineering has been stressed repeatedly in preceding articles of this series. Systems analysis is, of course, not a new technique. However, it has only recently been systematically applied to design problems involving the interaction of men and machines.

Obviously, an intelligent analysis of a system under design demands precise knowledge of its performance goals and of the contributions that subsystems and components make to over-all performance. Some of the techniques that are used to obtain, evaluate, and use such information are summarized in this concluding article of the human-factors series. Also presented are a listing of some of the more helpful human-factors engineering data sources, and a commentary on their general content and approach.

How to Analyze Performance

Undoubtedly, the most direct method of systems analysis is to measure the significant performance elements in an identical or nearly identical system already in operation. This procedure makes use of recognized job analysis and time-study techniques. The tools are the stop watch, process chart, simo chart, motion-picture photography, and recordings of communications-system traffic. On occasion, some of the more subtle techniques of the psychologist, such as those that record eye movements to determine which instrument is being observed, may also be used. The effects on operator performance of unusual environmental conditions—such as noise, heat, humidity, and fumes—can also be noted during such a study.

When objective measurements like those just described cannot be made, it may be necessary to resort to the use of interviews or questionnaires. Although the human element introduces unknown errors when such techniques are used, much valuable information can be obtained when they are applied with caution and skill.

If the system under design does not resemble one already in operation, direct measurement of the operating variables cannot, of course, be employed. As an alternate approach, the designer may study systems containing elements similar to those that are anticipated in the new system.

However, synthesis of data obtained in such a matter should be carried out with caution. Industrial engineers and psychologists have noted that when any one element in a sequence performed by a man is changed or eliminated, the remaining elements are affected. For example, it was found that some bricklayers use one set of motions to describe how they lay brick, use another set to teach an apprentice how to lay brick, and use still a third set when actually laying brick themselves. This phenomenon must be kept in mind by the designer who plans to synthesize data obtained by measurement of separate elements.

Although systems analysis may not permit exact prediction of how a new system will perform, it gives a reasonable estimate which is more satisfactory than one based on intuition, experience, or plain guess work.

Product Design

Optimizing a system from the human operator's standpoint often results in a design that is excessively costly or complex. Obviously, a compromise is then necessary. Since such compromises are the rule rather than the exception, it is vitally important that the engineer and the psychologist (or other human-factors consultant) work in close co-operation at all stages in the product design.

Development of a new product can be considered to pass through a number of more or less distinct stages:

1. The Idea Stage: Here, the need for an entirely new product or a major modification of an existing product is established; the general configuration of the man-machine system is conceived, and the feasibility of producing it is considered.
2. The Blueprint Stage: The idea is further refined in this stage; basic operational concepts are formulated, and methods for instrumenting the idea are set down on paper, critically examined, and revised.
3. The Mock-up Stage: Mock-ups or experimental models are constructed, and preliminary tests are conducted.
4. The Operational Test Stage: Experimental items are subjected to exhaustive tests to determine their suitability for general use; the product may then be accepted for general use or referred back to an earlier stage with recommendation for further work.
5. The Operational Use Stage: The product is marketed or installed for routine production-line use.

Table 1—Human-Factors in Product Design

Stages of Design	Contributions by Human-Factors Personnel
New product idea	• Advise on the general configuration. • Where appropriate, advise on which tasks should be performed by men and which should be performed by machines. • Provide information that will help in determining effectiveness of the system. • Start work on experimental problems for which answers will ultimately be required.
Blueprint	• Advise on design of specific components. • Consult on necessary design compromises.
Mock-up	• Check validity of previous design decisions. • Uncover problems not apparent in early stages. • Consult on design compromises.
Operational test	• Check further on previous design decisions. • Obtain additional information concerning refinements that might be made in design.
Operational use	• Obtain information that will be of value in new models or in designing new items.

Ideally, a human-factors engineer or consultant should be included in the group which considers a product at the *Idea* Stage, Table 1. Drawing upon their knowledge of human capabilities and limitations, these specialists contribute to decisions that concern the general product configuration. Where systems are very complex, they can give advice on which tasks are best performed by men and which are best performed by machines. Consideration can also be given to the tasks expected of the human operators, and to the ways in which design features may affect human performance. Specific answers can be provided at this first stage for use at the *Blueprint* or *Mock-up* stages. Thus, the risk of major design change at later stages of development can be minimized.

When an item enters the second or *Blueprint* stage, more detailed consideration must be given to the roles to be played by men and those to be played by machines. At this time, decisions are made concerning the design of specific components, and the human-factors engineering group can incorporate the results of preliminary experimentation and literature surveys.

When an item reaches the *Mock-up* stage, the validity of preliminary design decisions can be verified, and additional problems that have been difficult to visualize on paper can be uncovered. Alterations are then made in the design to accommodate newly discovered facts, and additional compromises can be made between requirements which conflict from engineering, psychological, and economic standpoints.

The participation of human-factors engineers in the *Operational Test* stage insures that the system will be critically examined for compatibility of man and machine. Such examination often provides clues that lead to additional design refinements.

Human-factors engineering people should always follow the product's use history after it has been placed on the market or production line. As in operational testing, the validity of previous decisions

Table 2—Secretary's Workplace Checklist

1. Is the seat adjustable from 15 in. to 18 in. from the floor?
2. Does the seat make an angle of from 3 to 5 deg with the horizontal?
3. Is the seat at least 15 in. wide and 15 in. deep?
4. Is the backrest at least 12 in. wide and 8 in. high?
5. Is there an angle of 105 deg between the seat and backrest?
6. Is the bottom of the table at least 24 in. from the floor?
7. Is the table at least 16 in. deep and 30 in. wide?
8. Is the sound level at the work space less than 45 db?
9. Are there between 20 and 50 ft-c of illumination on the work surface?
10. Can the temperature be maintained at 70 F?
11. Can the relative humidity be maintained between 30 and 70 per cent?
12. Can a ventilation rate of 1.2 cu ft per person per min be maintained?

Table 3—Man-Machine Checklist

1. Identification and discrimination	• **Has the workplace layout** been standardized? Are arrangements of controls and displays consistent with other workplaces which operators may use? • **Are displays and controls located** to insure quick and accurate identification? Are controls identifiable both by sight and by touch? • **Are controls far enough apart** to permit their location by "blind" reaching movements and to allow adequate clearance for operation (taking into account the clothing worn by the operator)?
2. Efficiency of operation	• **Are controls within easy working** distance of the operator? • **Have the more important** and frequently used controls and displays been given preferred positions? Are controls and displays grouped into patterns which aid in operation and observation? • **Is a hand (or foot) overloaded** with work which could be performed adequately by the other limb? Are controls that are operated in sequence located to call for a minimum of limb movement compatible with an easily learned movement pattern from one control to the next?
3. Vision	• **Are the most important** and frequently used displays located in the most favorable positions, normal to the line of sight? Are all displays readable from the normal head position of the operator, allowing for normal head rotation and restrictions imposed by helmets, goggles, and other headgear? • **Does miscellaneous equipment** obstruct the view of displays? Are displays hidden or can they be misread because of oblique viewing angles? • **Are displays which are used together** grouped together?
4. Interpretation	• **Are direction-of-movement relationships** between controls and controlled objects consistent and do they conform with natural habit patterns? • Are displays and controls patterned in a consistent functional arrangement?
5. Team operation	• **Do parts of consoles and panels** used concurrently by more than one member of a team meet all the above recommendations for each member? Is there interference in operations performed by crew members who must use the some control?

can be determined and leads obtained for improvement of future models.

▶ Using Basic Principles

When rules or principles for evaluating a product from the human-factors standpoint are set down on paper, the usual reactions are: 1. They are all obvious. 2. They merely reflect common sense. 3. No great skill or insight was required to prepare them. Although they may seem obvious, such guide rules have been formulated because a disturbingly large number of instances have been found where one or more have been violated.

In testing the adequacy of a design by use of organized checklists, the designer should take care that responses are specific to the system in question. For example, one familiar recommendation says: "Operators should not be expected to see without adequate illumination." For this reminder to be of value, one must ask two further questions: 1. "See what?" 2. "What constitutes adequate illumination for the task at hand?" A level of illumination that may be more than adequate for one task may be woefully inadequate for another. Obviously, such general principles represent excellent starting points, but all need further refinement when they are actually applied to a specific system.

In evaluating a man-machine system or component, the human-factors engineer usually makes a final check to determine the extent to which principles that should have been followed have, in fact, been followed. One way to do this is to rephrase the design principles as questions.

For example, if the checklist item says: "Select controls which permit each limb to be used effectively." The check question might ask: "Have controls been selected in such a way that each limb can be used effectively?" If the answer to this question is *No*, redesign is in order. If the answer is a qualified *Yes*—perhaps because of a design compromise—it is worth checking to make sure that the compromise with principle has been dictated by an important economic or engineering factor. If compromise was necessary, then the design is as good as can be obtained under the circumstances.

Checklists should always be as specific as possible. An excellent example of a checklist for layout of workplaces is presented in Table 2. Over-all evaluation of the man-machine system from a human-factors standpoint can be carried out with the aid of a checklist like that shown in Table 3.[4]

▶ Applying Human-Factors Data

Human-factors data, obtained by investigation or from the literature, must be critically evaluated before being applied to a specific design problem. Occasionally, such data can be applied directly. Human responses, however, are quite susceptible to change under varying test conditions. Furthermore, it is often difficult for the designer to decide whether experimental test conditions under which the data were obtained correspond to conditions in the operational system. In fact, there is usually just enough dissimilarity in conditions to raise the question: Do the data apply?

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[4] References are tabulated at end of article.

This state of indecision explains the use of psychologists in areas usually reserved for engineers. Obviously, extrapolation or generalization of human-factors data demands considerable knowledge of experimental procedures, psychological jargon, and unique statistical techniques, Table 4. Another important skill that the psychologist brings to bear on human-factors problems is his ability to carry out experiments involving human beings. This is not as simple as it may appear. Serious inferential errors can be committed by one who fails to consider all relevant variables, or who fails to account for variables that cannot be controlled. The required sophistication in psychological techniques is possessed by few design engineers. This is understandable, since nearly all human-engineering psychologists have been trained at the graduate level.

It is emphasized that the recommendation to make occasional use of psychologists in design does not rule out the use of design engineers in human-factors work. There are many problems that can be handled with minimum formal training in human-factors techniques. In fact, the psychologist can be considered as simply a specialist who is available for consultation when a particularly knotty problem arises.

Too often it is found that there are no data available that bear on the design problem under consideration. The unfortunate alternative requires the design engineer either to make an educated guess and hope for the best, or to conduct *ad hoc* experiments that will provide the missing data.

Obviously, guesswork should be kept to a minimum. Nor are hastily designed experiments entirely satisfactory, or economical. The reason is that the results of such tests can rarely be generalized to apply to other situations. As the human-factors field develops, there will be more general experiments conducted and more basic research carried out that will provide concrete help in design.

▶ How to Learn More

Treatment of any single facet of human-factors engineering has necessarily been brief in this series. Aim of the presentation has been to rough in the boundaries of the subject, and to give a sample of the available human-factors information as it applies in design.

To the designer who must contend increasingly with human limitations and capabilities, but who is a nonspecialist in the human-factors field, the key question is: What are the significant sources of human-factors data, and how do I keep abreast of new developments?

One of the first attempts to provide an answer is found in the Tufts College *Handbook of Human Engineering Data for Design Engineers.*[9] Purpose of the handbook was to survey all available psychological data pertinent to design, and to give brief descriptions of the experimental conditions that yielded the results. In general, the Tufts' handbook reports on human-factors experiments and makes no attempt to evaluate results.

A much shorter document, one which presents recommendations on the use of data without discussing the experiments, is the *Human Engineering Guide for Equipment Designers.*[7] The abundance of illustrations and the easy reading style of the guide make it readily understandable to the nonspecialist.

Table 4—Data-Validity Checklist

1. **Experimental Subjects:** To what extent were people who served as subjects in the experiment similar to those who will use the equipment? Consider such things as the following:
    - Sex differences
    - Experiences with the same or similar equipment
    - Specialized training appropriate to the task at hand
    - Physical condition
    - Aptitudes
    - Motivation
2. **Experimental Conditions:** How closely does the task required of the experimental subjects agree with the task required of those who will use the equipment? These points should be examined:
    - Speed of operation
    - Accuracy of operation
    - Complexity of the operation
    - Nature of stimuli indicating that some action is required
    - Nature of the controls or means whereby adjustments are to be made or action taken
3. **Experimental Environment:** To what extent do conditions under which the experiment was conducted differ from those under which the equipment operator will perform? Keep these items in mind:
    - Lighting
    - Heat, humidity, ventilation, noxious fumes
    - Surrounding noise level
    - Outside distractions
    - Extent to which fatigue and practice effects occured
4. **Experimental Design:** Were the experimental data handled in such a way that results obtained can be applied to other situations? Ask these questions:
    - Was a sufficient number of subjects used to provide stable measures of performance?
    - Were proper control groups of subjects used to insure that the phenomenon observed could not have have taken place without exposure to the experimental conditions?
    - Were the data analyzed in such a why that it is possible to make valid generalizations beyond the sample of subjects in question?

One of two texts devoted entirely to the human-factors engineering field is *Applied Experimental Psychology,*[3] which contains information originally presented as a lecture series at the Naval Post Graduate School. This book is a basic reference work in the field. Another text written primarily for engineers and managerial personnel is *Human Engineering.*[6] Straightforward presentation and extensive coverage provide the reader with considerable insight into the field.

A work not as well known as the foregoing because of its specialized subject is *Human Factors in Underseas Warfare.*[11] Of particular note are sections relating to fatigue, extreme environmental conditions, and morale. The Navy has also recently announced the publication of the *Human Engineering Bibliography,*[10] which selects and classifies the listings of two unpublished bibliographic collections. A total of 5666 references are tabulated in convenient categories. This bibliography can be obtained from the San Diego State College Foundation, San Diego 15, Calif.

Another excellent source of information will ultimately be the *Joint Services Human Engineering Guide,* being prepared under the direction of a committee of representatives from the three major armed forces. Chapters are being written by various individuals and organizations and are being released as technical reports prior to assembly in one volume. Three reports presently available are: 1. *Visual Presentation of Information.*[1] 2. *Layout of Workplaces.*[4] 3. *Design of Controls.*[5]

The problem of keeping abreast of the rapidly expanding literature in the field of human-factors engineering is a pressing one. Designers with government contracts can use the Armed Services Technical Information facility, which publishes periodic abstracts of work in all technical fields (including human-factors engineering) in both classified and unclassified editions.

Those who do not have military contracts must rely on the technical periodicals and journals. The *Journal of Applied Psychology*[12] and the *Journal of Experimental Psychology*[13] frequently carry articles of a human-factors nature. Abstracts of articles appearing in these journals, and many others, eventually make their appearance in the *Psychological Abstracts.*[14] All of these publications may be obtained from the American Psychological Association, 1333 Sixteenth St. N. W., Washington 6, D. C.

Publication of the journal, *Ergonomics,* has just been announced. *Ergonomics* will devote itself exclusively to articles concerning human factors in work, machine control, and equipment design, and will have international coverage. Although published in Great Britain, the journal may be obtained in the United States through the Academic Press, 111 Fifth Ave., New York 3, N. Y.

One difficulty with the psychological journals is the marked time lag in publication. The *Journal of Applied Psychology* suffers a time lag of nine months to a year, and the *Journal of Experimental Psychology* a lag of one year to eighteen months. Thus, the problem of currency of information is presented. Professional meetings also offer the designer a method of obtaining advance reports directly from the research man.

For designers with security clearance, a noteworthy meeting is the annual Human Engineering Conference, sponsored by the Office of Naval Research. Attendance at the meetings of the American Psychological Association is not restricted, and the meetings include more material of interest to human-factors personnel each year. The Society of Engineering Psychologists, a division of the American Psychological Association was organized recently, and this group is looking into ways to facilitate the flow of technical information.

The Human Factors Society was formally organized last fall. This group is not affiliated with any existing organization and, once it becomes fully operational, will also consider methods of facilitating dissemination of working human-factors data.

References and Bibliography

1. C. A. Baker and W. F. Grether—*Visual Presentation of Information,* USAF Wright Air Development Center Technical Report 54-160, August, 1954.
2. W. Bevan and R. M. Patton—*Fatigue, Stress, Bodily Change, and Behavior—Selected Bibliography,* Report ORD/108, AF Contract 33(616)-3745, December, 1956, Human Engineering Dept., Lockheed Aircraft Corp., Marietta, Ga.
3. A. Chapanis, W. R. Garner, and C. T. Morgan—*Applied Experimental Psychology,* John Wiley & Sons, New York, 1949.
4. J. H. Ely, R. M. Thomson, and J. Orlansky—*Layout of Workplaces,* WADC Technical Report 56-171, AD Document No. AD 110507, USAF Wright Air Development Center, September, 1956.
5. J. H. Ely, R. M. Thomson, and J. Orlansky—*Design of Controls,* WADC Technical Report 56-172, AD Document No. AD 118023, USAF Wright Air Development Center, November, 1956.
6. E. J. McCormick—*Human Engineering,* McGraw Hill Book Co., New York, 1957.
7. W. E. Woodson—*Human Engineering Guide for Equipment Designers,* University of California Press, Los Angeles, 1954.
8. *Ergonomics,* Academic Press Inc., 111 Fifth Ave., New York 3, N. Y.
9. *Handbook of Human Engineering Data for Design Engineers,* Technical Report 199-1-1, NavExos P-643, United States Dept. of Commerce, Office of Technical Services, Washington, D. C.
10. *Human Engineering Bibliography*—San Diego State College Foundation, San Diego, Calif., 1955.
11. *Human Factors in Undersea Warfare*—Committee on Undersea Warfare, National Research Council, Washington, D. C.
12. *Journal of Applied Psychology*—American Psychological Association, Washington, D. C.
13. *Journal of Experimental Psychology*—American Psychological Association, Washington, D. C.
14. *Psychological Abstracts*—American Psychological Association, Washington, D. C.
15. *Suggestions for Designers of Electronic Equipment*—United States Navy Electronic Laboratory, San Diego, Calif., 1955.

Copies of the entire "Human-Factors Engineering" series, bound with a heavy paper cover, can be obtained for $1.00 each from: Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio

They Say . . .

"For many years the bachelor's degree has been the accepted badge of admission to the engineering profession. But it is becoming more difficult at the undergraduate level to prepare a student adequately, and it is my belief that it will not be too long before a graduate degree is the minimum requirement in engineering, as is the case in the sciences."—JOHN T. RETTALIATA, *president, Illinois Institute of Technology.*

Here's how to combine the virtues of both in

Pneumatics + *Hydraulics*

SELECTING oil or air as the "best" fluid-power medium for application is a design problem which is often resolved without unusual difficulty. Each of these systems can lay claim to performance characteristics that are, to some extent, unique.

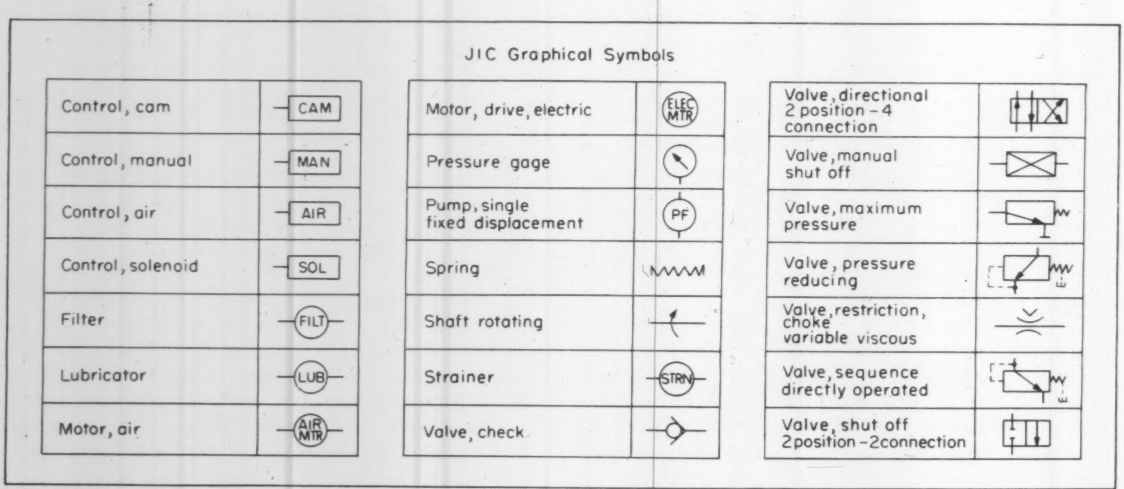
The oil-hydraulics circuit, for example, offers high working forces, compact components, smoothly controlled motion, and a "stiff" system for use where dynamic response or positional accuracy are first-order factors. On the other hand, the pneumatic system has the advantages of high operating speeds, absence of fire hazard, cleanliness, and relatively low cost of components. An evaluation of these characteristics often allows quick selection of either an all-pneumatic or an all-hydraulic system.

▶ Two-Media Systems

In certain other design situations, however, a blending of these separate system characteristics is desired. This suggests the use of a dual-media system —one which combines both air and oil circuits. Such an arrangement provides both the quick-response characteristics of air components and the easily modulated control action of the oil-hydraulics circuit.

Often, the combination system reduces the space requirements and initial cost of single-fluid circuits. It has also proved advantageous in explosive environments, since combined air and oil circuits can give a feed rate comparable to an all-hydraulic circuit without the expense of explosionproof motors and starters. Another application is in a fume-contaminated atmosphere which may cause hydraulic-fluid trouble in an all-oil circuit, particularly if the fluid reservoir were ventilated. The closed-circuit hydraulic loop in the combined system provides greater protection against fluid contamination.

The following eight circuits, which represent typical applications of combined air and oil circuitry, illustrate the flexibility of the technique and emphasize further design advantages.


JIC Graphical Symbols
Control, cam
CAM
Control, manual
MAN
Control, air
AIR
Control, solenoid
SOL
Filter
FILT
Lubricator
LUB
Motor, air
AIR MTR
Motor, drive, electric
ELEC MTR
Pressure gage
Pump, single fixed displacement
PF
Spring
Shaft rotating
Strainer
STRN
Valve, check
Valve, directional 2 position - 4 connection
Valve, manual shut off
Valve, maximum pressure
Valve, pressure reducing
Valve, restriction, choke variable viscous
Valve, sequence directly operated
Valve, shut off 2position - 2connection

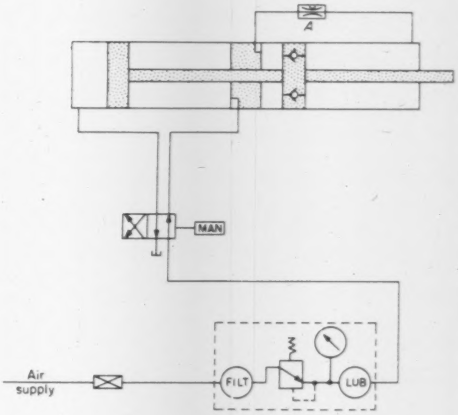
TWO-FLUID SYSTEMS

By **H. L. STEWART and J. M. MORITZ**
Logansport, Ind.

1

Combination-Cylinder Circuit

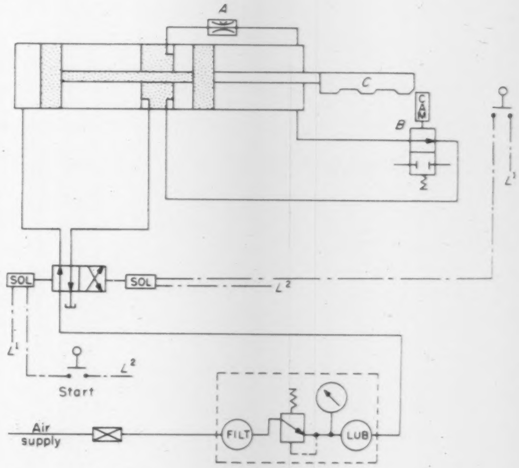
One of the basic circuits in the two-fluid system is that built around a two-section or combination actuating cylinder. Designed for applications requiring smoothly controlled motion with relatively low operating forces, the combination cylinder utilizes compressed air to generate the motivating force (rear section) and an oil-filled, closed-circuit front section to control rate of rod advance. Speed of advance of the piston rod is controlled by the setting of orifice *A* which meters the rate of oil flow in the closed circuit. Check valves in the piston are optional additions which permit rapid return of the piston rod. Net actuating force on the rod is the pneumatic force (pressure times area) minus the friction losses of rod and piston packings.



2

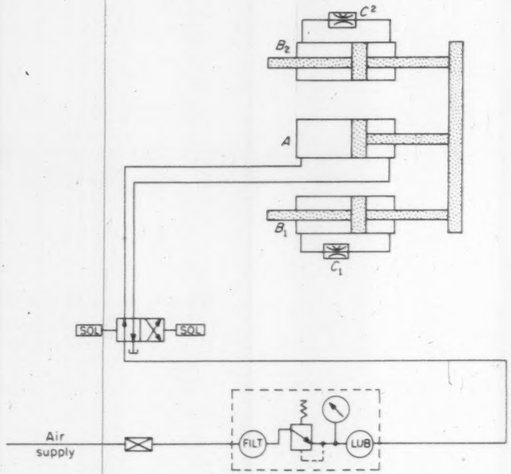
Skip-Feed Circuit

The two-media combination cylinder and a cam valve are shown working together to provide skip-feed action for machine tool and similar applications. Alternating fast and slow advances of the piston rod are programmed by cam valve *B*, which is actuated by cam plate *C*. Orifice *A* controls the feed rate.



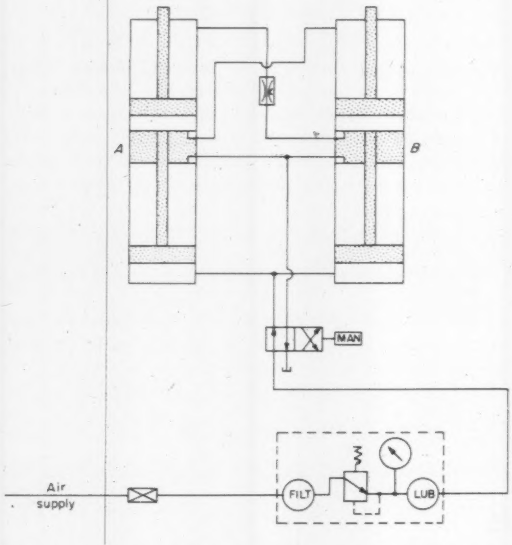
3 Parallel-Cylinder Circuit

Mechanically paralleling air and oil cylinders is another technique for combining the performance advantages of pneumatic and hydraulic circuits. Here, air cylinder *A* and two double-end-rod oil cylinders B_1 and B_2 are mounted in parallel to provide force and control actions. Again, metering of oil through orifices C_1 and C_2 provides an adjustment for feed rate. An alternate arrangement of this system uses a single hydraulic control or check cylinder, mounted either parallel to or in line with an air cylinder.



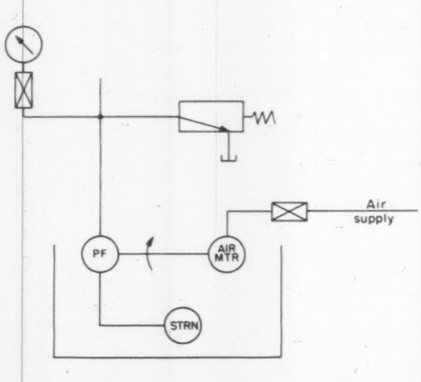
4 Synchronization Circuit

A recurring problem in fluid-power application is synchronization of the rod advances of two or more cylinders. The method shown here utilizes two combination air-oil cylinders, *A* and *B*, actuated by compressed air directed to their blind ends. The cross-over circuit, connecting the cylinder front sections, ensures synchronization of movement of the piston rods. Typical application of such an arrangement is on a four-port press where equal pressures must be exerted at each corner.



5 Air-Motor Pump Drive

The use of the two media—air and oil—is often desirable in applications where explosion or fire hazards exist. The circuit illustrated here uses compressed air, either from a central system or from a remotely located portable compressor, to drive an air motor which, in turn, drives a hydraulic pump. Where the pump is a constant-volume unit, compressed air to the pump can be modulated to provide some of the characteristics of a variable-volume system.



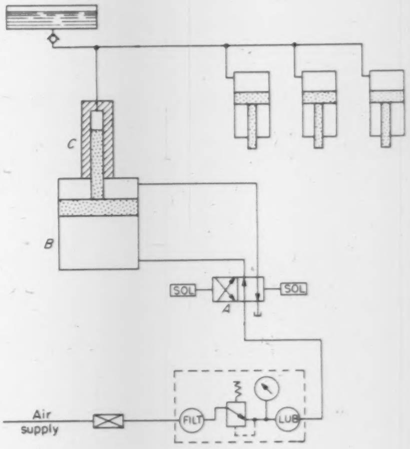
6

Intensifier Circuit

Heat generation often presents a problem in high-pressure hydraulic systems, especially where long standby periods are involved. Combination of a pneumatic intensifier with a closed, high-pressure hydraulic circuit provides a means of reducing such heat generation.

Compressed air applied to the lower section, *B*, of the intensifier moves the piston forward and forces oil out of section *C* at high pressure. The oil then actuates the three small hydraulic cylinders. If the pneumatic section of the intensifier has, for example, a 24-in. diam, and the oil piston a 2-in. diam, then a 100-psi air input generates an oil pressure of 14,400 psi. This pressure can be held long periods without creating excessive heat.

Work performed in the closed circuit must, of course, be completed before the intensifier reaches the end of its stroke, since pressure then drops off quickly. Double-acting intensifiers are available to provide full oil pressure in both directions of piston movement.

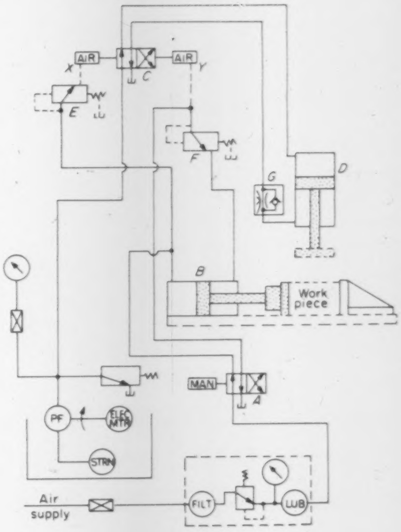


7

Pilot-Valve Circuit

Pilot-operated four-way hydraulic valves, using compressed air as the pilot medium, offer another means of combining the rapid action of air with the controlled-force capabilities of oil. The clamp-broach circuit illustrated here makes use of a pneumatic cylinder for the clamping action and a hydraulic cylinder for broaching the workpiece. Sequence of operation is as follows:

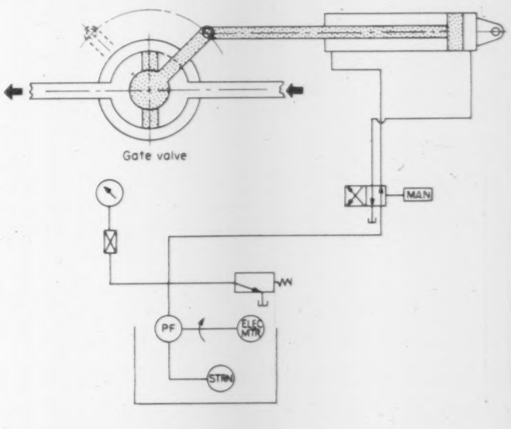
1. Operator shifts four-way, two-position air valve *A*, directing air to the blind end of clamp cylinder *B*.
2. Air pressure builds up when workpiece is clamped, opening sequence valve *E* and sending air to pilot connection X of four-way, two-position hydraulic valve *C*.
3. Shifting of the spool in valve *C* directs high-pressure oil to the blind end of broach cylinder *D*; rate of rod movement is controlled by setting of flow-control valve *G*.
4. When the broaching operation has been completed, operator shifts valve *A* to its initial position. Air then flows to pilot port *Y* of valve *C*, shifting its spool and directing oil to the rod end of the broach cylinder.
5. Air pressure buildup opens sequence valve *F*, directing air to the rod end of clamp cylinder *B*. The workpiece is then released and the cycle is completed.



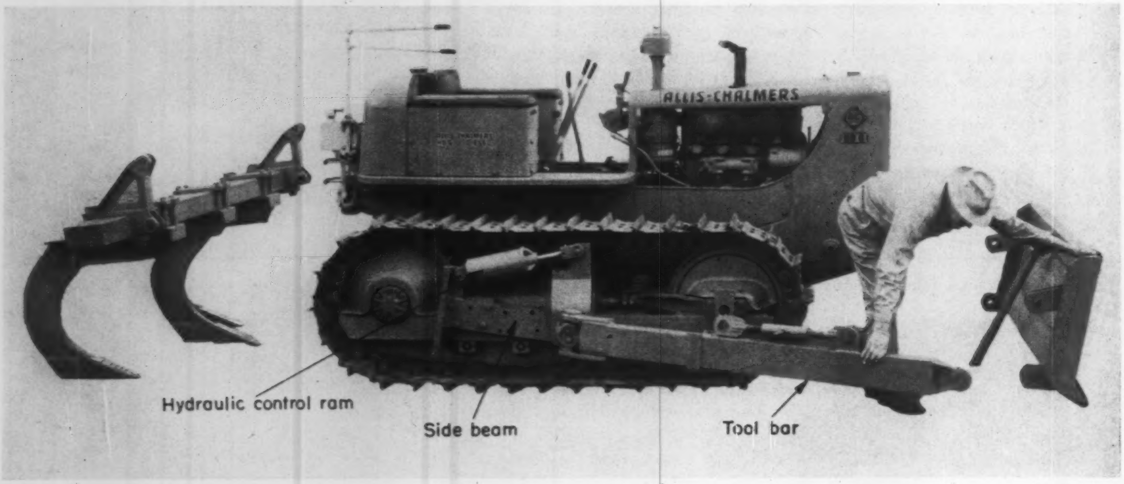
8

Air-Valve Operating Circuit

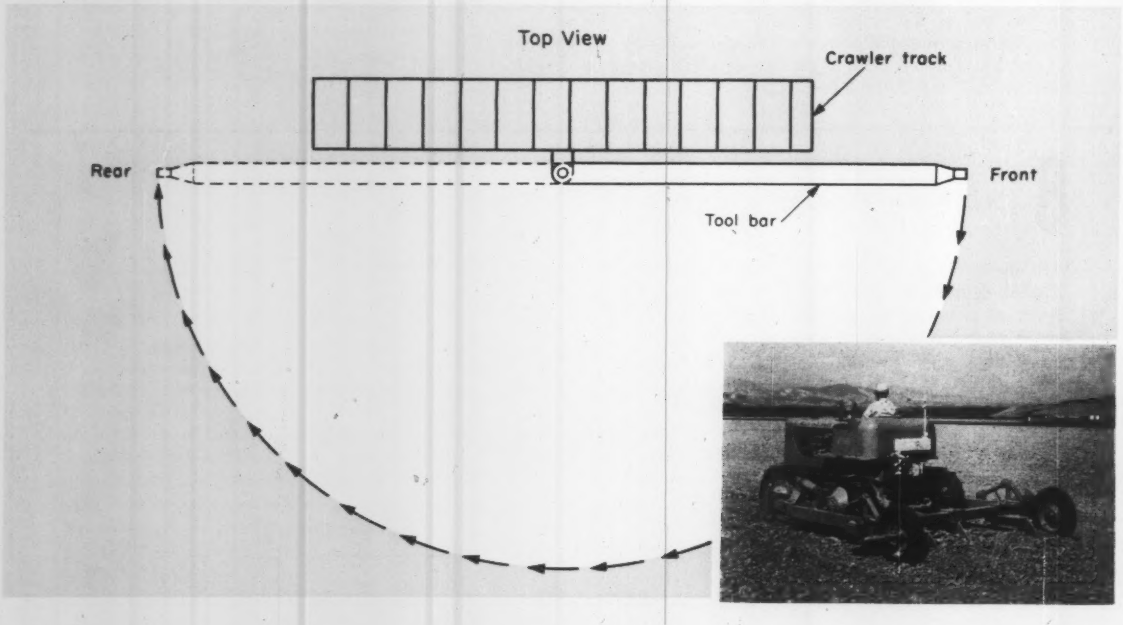
In the operation of large pneumatic valves, it is often desirable to move the valve mechanism slowly so as to reduce air-surge effects. Here, a circuit is shown wherein a large air valve is operated by a small hydraulic cylinder. The four-way hydraulic control valve—usually located at a remote point—can be the two or three-position type. Advantage of the three-position valve is that it permits inching of the large pneumatic valve, and allows the valve to be stopped at any intermediate position.



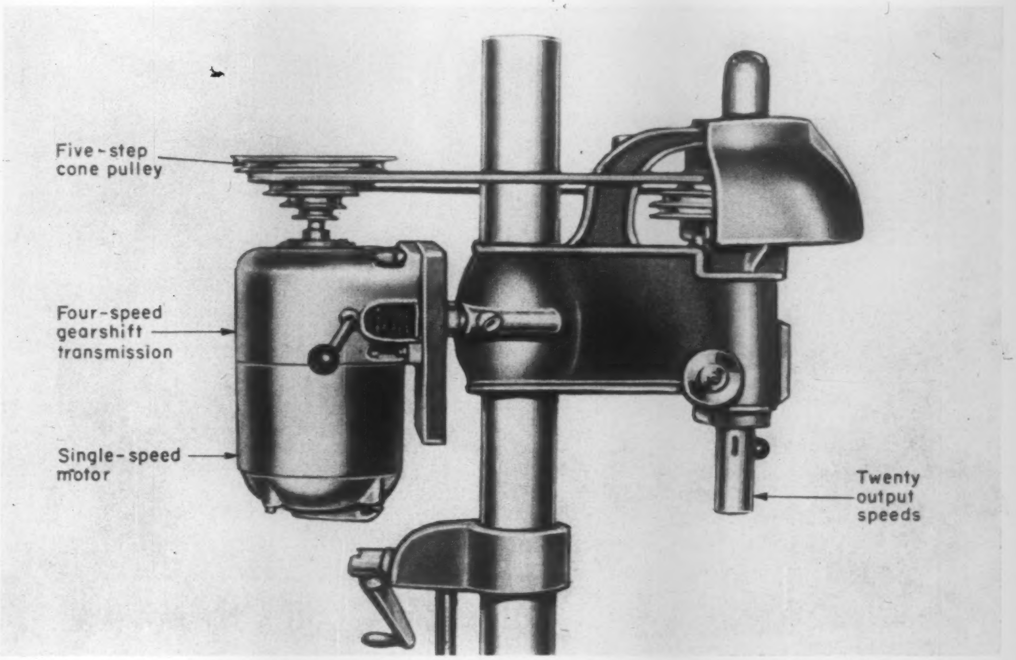
Tool Bar Pivots 180 Degrees To Mount Implements Front and Rear

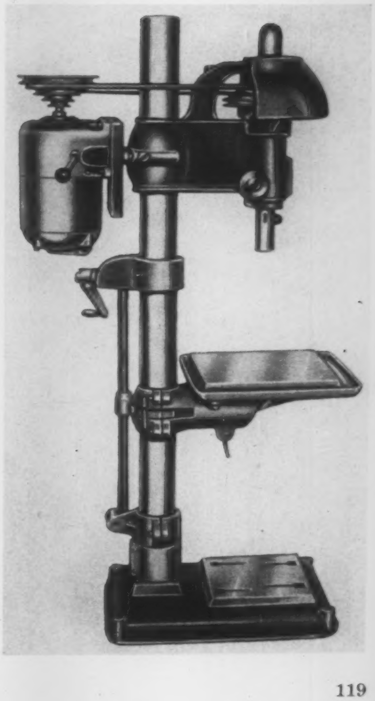

ALLIS-CHALMERS
Hydraulic control ram
Side beam
Tool bar

QUICK CHANGEOVER from rear-mounted implements to front-mounted units is made possible with new tool bars built for Allis-Chalmers HD-6 crawler tractors. Designed for attachment at the pull point on the side beams of the tractor, the tool bars are designed for full-range operation of the tractor's hydraulic rams with either front or rear-mounted tools. After four pin fasteners are removed from a given implement, the tool bars are easily swung around from front to back of the machine or vice versa.


Top View
Crawler track
Rear
Front
Tool bar

Combined Pulley and Gearshift Gives 30-to-1 Speed Range





WIDE SPEED RANGE DRIVE is offered at minimum cost by a design arrangement which uses a four-speed gearshift motor in combination with a multistep cone-pulley belting arrangement. According to a recent study made at the Lima Electric Motor Co. Inc., Lima, Ohio, in applying their Selective-Speed gearshift drives on drill presses, 30-to-1 speed ranges can be obtained with nearly constant-horsepower outputs using a single-speed motor. For example, a four-speed gearshift drive powering a five-step cone-pulley belt drive could produce the following speeds: 1. Fourth gear—2965, 1782, 1088, 663, 395. 2. Third gear—2220, 1334, 814, 496, 296. 3. Second gear—1483, 891, 544, 331, 197. 4. First gear—737, 443, 270, 165, 98. The lower speeds which can be obtained in first and second gear make drill presses suitable for spot facing, chamfering, counterboring, reaming, and tapping, in addition to drilling.

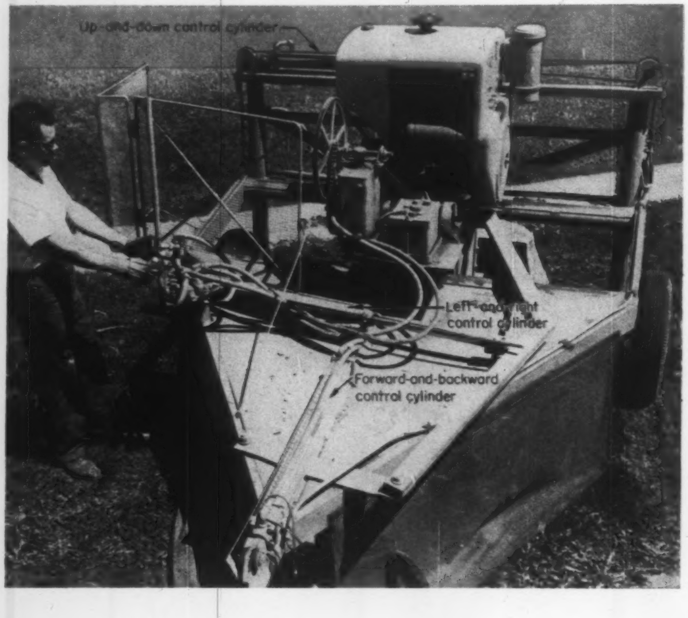
If a two-speed constant-horsepower motor is used with this same mechanical drive arrangement, forty output speeds can be provided.

Hydraulically Positioned Cutting Wheel Controlled in Three Directions of Travel

THREE HYDRAULIC CYLINDERS control cutting action of novel machine designed to shred tree stumps. One cylinder moves the entire engine and high-speed cutter assembly sideways on the two V-shaped tracks.

A second cylinder controls cutter height by raising or lowering the frame through wire cables.

The other cylinder extends the hitch which, in effect, moves the whole machine and cutter back horizontally. After each pass across the stump, the hitch tube, which is connected to a tractor or truck, is extended 1 to 2 in.


Up-and-down control cylinder
Left-and-right control cylinder
Forward-and-backward control cylinder

DRIVE POWER for the cutting rotor and for developing hydraulic pressure for control is provided by a Wisconsin engine. The machine can remove stumps of practically any size down to a depth of 10 in. below the surface of the ground. The equipment is built by the Vermeer Mfg. Co., Pella, Iowa.

Principles and practices of

Constant-Load Cam Design

for high-speed operation

By JOHN A. CARLSON*
Chief, Engineering Analysis Dept.
Product Development and Research Organization
Teletype Corp.
Chicago, Ill.

INCREASING emphasis on high speed and light weight has intensified the dynamic problems of mechanism design. One problem is the development of cam-follower systems to withstand the loads imposed by high-speed operation.

The need for cams with uniform loading has been recognized for some time. In this analysis, a method is given for calculating the contour of a constant-load cam with which it is desired to accelerate or decelerate a mechanism, with the main loads resulting from component inertia. Here, this inertia is associated with a translating mass, the cam moving perpendicular to the direction of motion of the mass, Fig. 1. However, other configurations of cam and inertia could be treated by defining an equivalent mass and equivalent friction coefficients.

In this approach, the differential equation for the cam contour is reduced to dimensionless form, involving only the coefficients of friction. Solutions to this differential equation are found for various values of the coefficients of friction. Equations for accelerating and decelerating cams are then developed for determination of dimensionless cam co-ordinates for any values of the friction coefficients.

Comparison of constant-load and parabolic cams shows the reduction in cam loads made possible by the constant-load design.

Other points considered in this discussion include ways of applying the dimensionless cam paths to actual cams. For instance, use of the

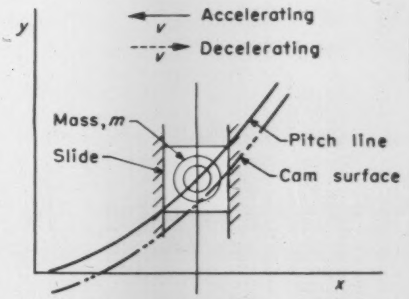


Fig. 1—Constant-load cam-follower system in which follower mass is constrained to translate linearly and cam surface moves with a constant velocity.

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*Formerly with Armour Research Foundation, Illinois Institute of Technology, Chicago, Ill.

digital computer to perform cam calculations can save time and provide greater accuracy with less chance of error. In addition, the method of obtaining the most efficient cam path to transport a mass through a given distance by means of a cam is described.

As will be shown by example, the constant-load cam can also be used to generate cam paths with varying load. These would be useful to permit gradually increasing or decreasing cam loads leading into or out of constant-load paths.

Force and Motion Analysis: The system to be considered consists of a mass which is constrained to translate linearly and a cam surface which moves with a constant velocity, v, normal to the line of motion of the mass, Fig. 1. A cam follower is attached to the mass which follows the cam surface.

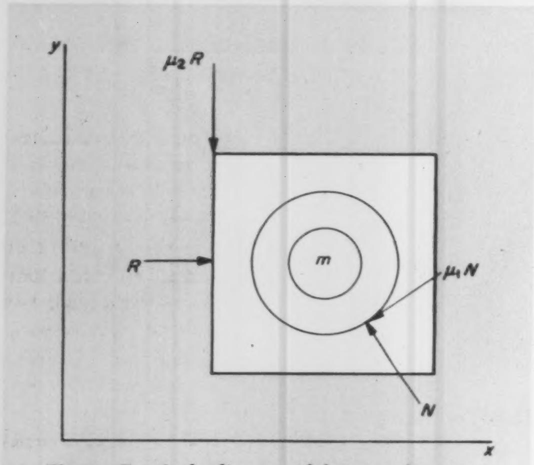

Fig. 2—Free-body diagram of forces acting on accelerating follower mass of system shown in Fig. 1.

If the curvature of the cam surface is always positive and the motion of the cam is in the direction shown in Fig. 1, mass m will be accelerated in the positive y direction. Motion of the cam in the opposite direction results in deceleration of the mass. Co-ordinates of the cam are x and y. These co-ordinates move with the cam. It is seen that the analysis would be the same if the cam were assumed to be stationary and the mass moved with constant velocity v in the x direction.

A free-body diagram of the mass while accelerating is shown in Fig. 2. Forces acting on the mass are normal cam load N, cam friction force $\mu_1 N$, slide reaction R and slide friction force $\mu_2 R$. Symbols are defined in Nomenclature. From consideration of these forces, the differential equation of motion of the accelerating mass can be written:

$$m \frac{d^2 y}{dt^2} = N \frac{1 - \mu_1 y'}{[1 + (y')^2]^{1/2}} - \mu_2 |R| \tag{1}$$

where,

$$R = N \frac{y' + \mu_1}{[1 + (y')^2]^{1/2}} \tag{2}$$

In deceleration, the friction forces will be in the opposite direction and the differential equation of motion of the mass becomes

$$m \frac{d^2 y}{dt^2} = N \frac{1 + \mu_1 y'}{[1 + (y')^2]^{1/2}} + \mu_2 |R| \tag{3}$$

where,

$$R = N \frac{y' - \mu_1}{[1 + (y')^2]^{1/2}} \tag{4}$$

Since y is a function of x,

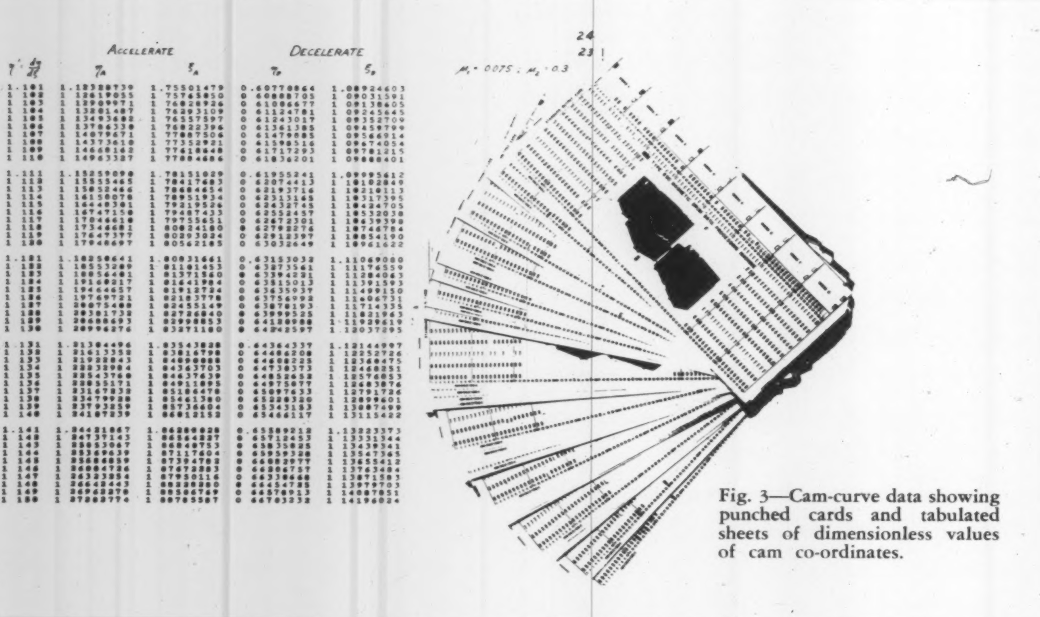

Fig. 3—Cam-curve data showing punched cards and tabulated sheets of dimensionless values of cam co-ordinates.

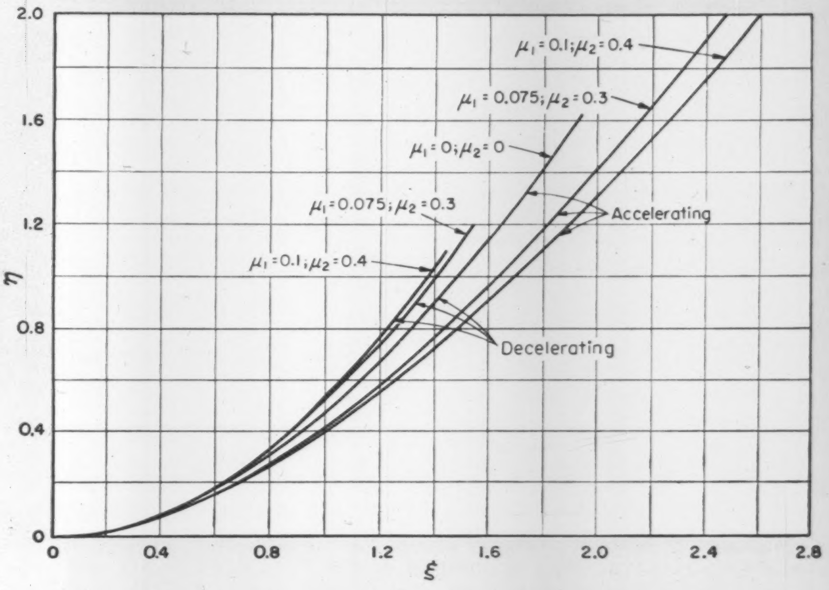

Fig. 4—Dimensionless constant-load cam paths for different values of friction coefficients of the cam follower and the slide.

$$\frac{dy}{dt} = \frac{dy}{dx}\,\frac{dx}{dt} = y'\,\frac{dx}{dt}$$

and

$$\frac{d^2y}{dt^2} = y''\left(\frac{dx}{dt}\right)^2 + y'\,\frac{d^2x}{dt^2} \tag{5}$$

Based on the relationships,

$$\frac{dx}{dt} = v$$

$$\frac{d^2x}{dt^2} = 0$$

substituting Equation 5 into Equations 1 and 3 gives, respectively,

$$mv^2\,y'' = N\,\frac{1 - \mu_1\,y'}{[1 + (y')^2]^{1/2}} - \mu_2\left|N\,\frac{y' + \mu_1}{[1 + (y')^2]^{1/2}}\right| \quad \ldots\ldots(6)$$

and,

$$mv^2\,y'' = N\,\frac{1 + \mu_1\,y'}{[1 + (y')^2]^{1/2}} + \mu_2\left|N\,\frac{y' - \mu_1}{[1 + (y')^2]^{1/2}}\right| \quad \ldots\ldots(7)$$

It is desired to obtain the solutions to Equations 6 and 7 when cam load N is a positive constant.

Equations 6 and 7 can be reduced to dimensionless form by making the following transformation of variables:

$$y = a\eta \tag{8}$$

$$x = a\xi \tag{9}$$

where,

$$a = \frac{mv^2}{N} \tag{10}$$

Thus, for the accelerating cam, designated by the subscript *A*,

$$\eta_A'' = \frac{1 - \mu_1\,\mu_2 - (\mu_1 + \mu_2)\,\eta_A'}{[1 + (\eta_A')^2]^{1/2}} \tag{11}$$

and for the decelerating cam, designated by the subscript *D*,

$$\eta_D'' = \frac{1 + \mu_1\,\mu_2 + (\mu_1 - \mu_2)\,\eta_D'}{[1 + (\eta_D')^2]^{1/2}}, \quad \eta_D' \le \mu_1 \tag{12}$$

$$\eta_D'' = \frac{1 - \mu_1\,\mu_2 + (\mu_1 + \mu_2)\,\eta_D'}{[1 + (\eta_D')^2]^{1/2}}, \quad \eta_D' \ge \mu_1 \tag{13}$$

In the latter case, the absolute-value sign has

Nomenclature*

a = Proportionality constant, L
b = Constant (Equation 26), L
C = Constant of integration
c = Constant (Equation 27), L
d = Displacement (Fig. 8), L
e = Displacement (Fig. 8), L
f, g = Functions of slope, yielding ξ and η
k = Parabola proportionality constant, L^{-1}
m = Mass of follower, M
N = Normal cam load, MLT^{-2}
R = Normal slide reaction, MLT^{-2}
s = Distance along cam path, L
t = Time, T
Δt = Time increment, T
v = Velocity of cam, LT^{-1}
W = Energy dissipated by friction, ML^2T^{-2}
x, y = Cam co-ordinates, L
y', y'' = Notation for first and second derivatives, respectively, of y with respect to x.
μ_1, μ_2 = Coefficients of friction of cam follower and slide, respectively
ξ, η = Dimensionless cam co-ordinates
η', η'' = Notation for first and second derivatives, respectively, of η with respect to ξ

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*Units are given in general terms: M = mass, L = length, T = time. Any consistent set of units can be used for calculations.

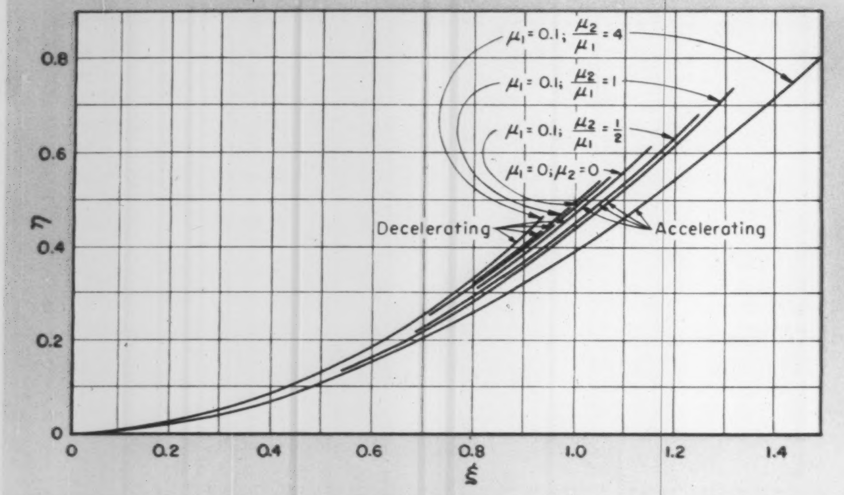


Fig. 5—Dimensionless constant-load cam curves for different values of friction-coefficient ratio μ_2/μ_1

been eliminated in favor of breaking up the equation into two forms for different ranges of the slope, η_D'. The boundary conditions for these equations are: Equation 11, at $\xi_A = 0$, $\eta_A = \eta_A' = 0$; Equations 12 and 13, at $\xi_D = 0$, $\eta_D = \eta_D' = 0$, and the solutions are continuous when $\eta_D' = \mu_1$.

The solutions of Equations 11, 12 and 13 can be written in parametric form by integrating the equations once directly and once after making the substitution,

$$\eta'' = \eta' \frac{d(\eta')}{d\eta} \tag{14}$$

treating η' as a variable. Thus, Equation 11 yields

$$\xi_A = \frac{\mu_1 + \mu_2}{1 - \mu_1 \mu_2} \eta_A + \frac{\eta_A' [1 + (\eta_A')^2]^{1/2}}{2(1 - \mu_1 \mu_2)} + \frac{\ln \{ \eta_A' + [1 + (\eta_A')^2]^{1/2} \}}{2(1 - \mu_1 \mu_2)} \tag{15}$$

$$\eta_A = \int_0^{\eta_A'} \frac{\eta_A'[1 + (\eta_A')^2]^{1/2}}{1 - \mu_1 \mu_2 - (\mu_1 + \mu_2)\eta_A'} d(\eta_A') \tag{16}$$

This form is advantageous for purposes of numerical computation.

For the decelerating cam, from Equation 12 ($\eta_D' \leqq \mu_1$),

$$\xi_D = \frac{\mu_2 - \mu_1}{1 + \mu_1 \mu_2} \eta_D + \frac{\eta_D' [1 + (\eta_D')^2]^{1/2}}{2(1 + \mu_1 \mu_2)} + \frac{\ln \{ \eta_D' + [1 + (\eta_D')^2]^{1/2} \}}{2(1 + \mu_1 \mu_2)} \tag{17}$$

$$\eta_D = \int_0^{\eta_D'} \frac{\eta_D'[1 + (\eta_D')^2]^{1/2}}{1 + \mu_1 \mu_2 + (\mu_1 - \mu_2)\eta_D'} d(\eta_D') \tag{18}$$

and from Equation 13 ($\eta_D' \geqq \mu_1$),

$$\xi_D = -\frac{\mu_1 + \mu_2}{1 - \mu_1 \mu_2} \eta_D + \frac{\eta_D'[1 + (\eta_D')^2]^{1/2}}{2(1 - \mu_1 \mu_2)} + \frac{\ln \{ \eta_D' + [1 + (\eta_D')^2]^{1/2} \}}{2(1 - \mu_1 \mu_2)} + C \tag{19}$$

where,

$$C = \xi_D \Big|_{\eta_D' = \mu_1} + \frac{\mu_1 + \mu_2}{1 - \mu_1 \mu_2} \eta_D \Big|_{\eta_D' = \mu_1} - \frac{\mu_1(1 + \mu_1^2)^{1/2} + \ln[\mu_1 + (1 + \mu_1^2)^{1/2}]}{2(1 - \mu_1 \mu_2)} \tag{20}$$

$$\eta_D = \int_{\mu_1}^{\eta_D'} \frac{\eta_D'[1 + (\eta_D')^2]^{1/2}}{1 - \mu_1 \mu_2 + (\mu_1 + \mu_2)\eta_D'} d(\eta_D') + \eta_D \Big|_{\eta_D' = \mu_1} \tag{21}$$

The integrals in the expressions for η_A and η_D must be evaluated numerically.

If friction is neglected ($\mu_1 = \mu_2 = 0$), the accelerating and decelerating cams become identical, the integral expression for η becomes elementary, and the co-ordinates of the cam path can be written in the parametric form,

$$\xi = \frac{\eta'}{2} \left[1 + (\eta')^2 \right]^{1/2} + \frac{1}{2} \ln \left\{ \eta' + [1 + (\eta')^2]^{1/2} \right\} \tag{22}$$

$$\eta = \frac{1}{3} \left[1 + (\eta')^2 \right]^{3/2} - \frac{1}{3} \tag{23}$$

It is possible to eliminate η' between these two equations, yielding the relation between ξ and η,

$$\xi = \frac{1}{2} \left[3^{2/3} \left(\eta + \frac{1}{3} \right)^{2/3} - 1 \right]^{1/2} + 3^{1/3} \left(\eta + \frac{1}{3} \right)^{1/3} + \frac{1}{2} \ln \left\{ \left[3^{2/3} \left(\eta + \frac{1}{3} \right)^{2/3} - 1 \right]^{1/2} + 3^{1/3} \left(\eta + \frac{1}{3} \right)^{1/3} \right\} \tag{24}$$

Dimensionless Cam Curves: For given values of coefficients of friction μ_1 and μ_2 of the cam follower and the slide, cam co-ordinates ξ_A, η_A, ξ_D, and η_D for accelerating and decelerating conditions can be computed as functions of the slope η'. These computations are readily executed by means of a digital computer. Fig. 3 shows the results of such computations in punched card and tabulated forms. These may be used for further computations of actual cam paths.

Dimensionless cam paths are plotted in Fig. 4 for cases with and without friction. In Fig. 5, the cam paths are plotted for different values of the ratio of friction coefficients, μ_2/μ_1.

The limiting cam slope for accelerating with friction present can be obtained from Equation 16 by setting the denominator of the integrand equal to zero. Thus, this limiting slope for the system shown in Fig. 1 is

$$\eta_A' = \frac{1 - \mu_1 \mu_2}{\mu_1 + \mu_2} \qquad (25)$$

If this slope were approached in a finite cam, the cam load would become infinite and the mechanism would jam. Without friction, the limiting slope becomes infinite. However, even in this case, it is not possible to go to very large slopes in a limited travel without very high cam loads, except when moving with very low velocity.

From Fig. 4 it is seen that increasing the friction coefficients results in reducing the curvature of the accelerating cam and increasing the curvature of the decelerating cam. The shapes of the curves are essentially the same. Varying the ratio of the friction coefficients μ_2/μ_1 does not change the general shape of the curves.

It also can be noted that the deviation of curves with friction away from the curve for no friction is approximately proportional to the sum of the friction coefficients, indicating that the effects of friction of the cam follower and the slide are the same. This conclusion may also be drawn from analysis of the cam path differential Equations 11 and 13. Here, it is seen that, in the dominant factor containing μ_1 and μ_2, $(\mu_1 + \mu_2)\eta'$, the friction coefficients appear as a sum which is commutable. The same is not true for Equation 12; however, this equation applies to only a small portion of the paths for practical values of μ_1.

Parabolic vs. Constant-Load Cam Paths: A curve function commonly used in cams for accelerating and decelerating masses in mechanisms is the parabola which prescribes a constant acceleration of the mass. An example has been chosen to illustrate the differences in the cam loads which are obtained using parabolic and constant-load cam paths. In this example, friction has been neglected.

The problem is to translate a mass m a given distance in a certain time with a cam which travels at constant speed. Fig. 6 shows parabolic and constant-load cam paths which could be used for this purpose. In Fig. 7, the cam loads are plotted for the two cam paths.

The cam load for the parabolic cam path rises to peaks which are much higher than for the constant-load design. Likewise, any other cam path used would produce peak loads greater than the constant-load path. Thus, the constant-load cam path will give the least load on the cam to accomplish the task set forth in this example.

Application of Constant-Load Cam: Once the coefficients of friction for the cam follower and the slide are known, the dimensionless cam path is determined. An actual cam path is established by

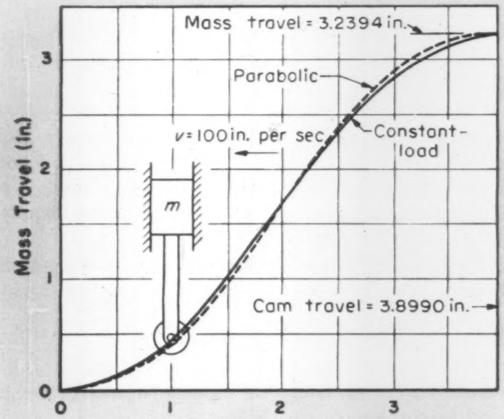


Fig. 6—Comparison of parabolic and constant-load cam paths developed to perform identical functions.

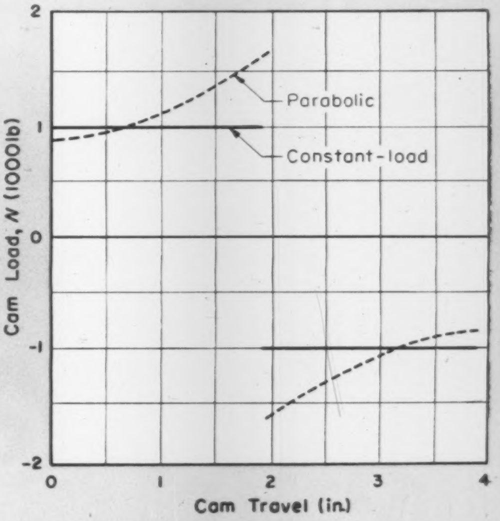


Fig. 7—Comparison of cam loads for parabolic and constant-load cam paths of Fig. 6.

the choice of the constant a (Equation 10) which is substituted into Equations 8 and 9. This constant could be chosen directly knowing the values of m, v, and N; for instance, taking N as the maximum permissible cam load, or determining it by other specifications of the cam path.

If it is desired to join two points through which mass m is to be moved by a constant-load cam, the cam path would be completely specified by co-ordinates x_1, y_1 and x_2, y_2 of the points, corresponding slopes y_1' and y_2' at these points, and constant a. However, it is not possible to choose all of these variables arbitrarily. To determine how many of these variables can be chosen independently, consider the following set of equations:

$$x_1 = a\xi_1 + b \tag{26}$$

$$y_1 = a\eta_1 + c \tag{27}$$

$$x_2 = a\xi_2 + b \tag{28}$$

$$y_2 = a\eta_2 + c \tag{29}$$

$$\xi_1 = f(y_1') \tag{30}$$

$$\eta_1 = g(y_1') \tag{31}$$

$$\xi_2 = f(y_2') \tag{32}$$

$$\eta_2 = g(y_2') \tag{33}$$

where b and c are co-ordinate translation constants, and the functions f and g are given by Equations 15 and 16, 17 and 18, or 19 and 21, since $y' = \eta'$. Thirteen constants are involved in these eight independent equations; thus, only five of these constants can be chosen arbitrarily to completely specify the cam path. For example, x_1, y_1, y_1', x_2, and y_2 may be chosen.

As an example of a specific application of the constant-load cam, the problem is posed to move a mass from one position to another in a given time Δt with a cam moving with a certain velocity v, Fig. 8. The distance through which the mass is to be moved is d, and the displacement of the cam during the movement of the mass is $e = v\,\Delta t$. It is desired to effect this movement of the mass with the least possible loss in energy. As shown in Fig. 8, it is possible to use a number of different cam paths.

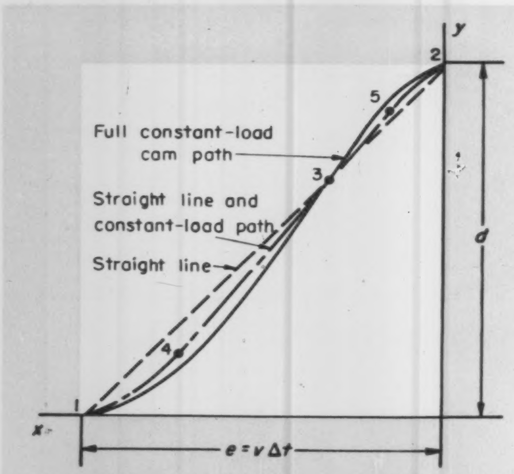

y
2
5
Full constant-load cam path
3
Straight line and constant-load path
Straight line
4
1
x
d
e = v Δt

Fig. 8—Comparison of different cam paths that could be used to translate a mass through a given distance.

The least cam load and consequently the longest cam life would result if a full constant-load cam path were used. In this case, the mass would be accelerated along the cam path from point 1 to 3 and decelerated from point 3 to 2, the cam load being constant. If point 1 is the origin of an x, y co-ordinate system with e being along the x axis, co-ordinates of the cam path may be computed from dimensionless constant-load cam co-ordinates ξ_A, η_A, ξ_D and η_D, by using the following equations:

From point 1 to 3,

$$x = a_{13}\,\xi_A + b_{13} \tag{34}$$

$$y = a_{13}\,\eta_A + c_{13} \tag{35}$$

From point 3 to 2,

$$x = a_{32}\,\xi_D + b_{32} \tag{36}$$

$$y = a_{32}\,\eta_D + c_{32} \tag{37}$$

Since $y' = \eta' = 0$ at points 1 and 2, $x_2 = e$, $y_2 = d$, $\xi_{A1} = \eta_{A1} = \xi_{D2} = \eta_{D2} = 0$, $b_{13} = 0$, $b_{32} = e$, $c_{13} = 0$, $c_{32} = d$.

At point 3,

$$a_{13}\,\xi_{A3} = a_{32}\,\xi_{D3} + e$$

$$a_{13}\,\eta_{A3} = a_{32}\,\eta_{D3} + d$$

or

$$a_{13}\,\xi_{A3} - a_{32}\,\xi_{D3} = e \tag{38}$$

$$a_{13}\,\eta_{A3} - a_{32}\,\eta_{D3} = d \tag{39}$$

Taking the decelerating load, which acts in a downward direction, equal to the accelerating load gives

$$a_{32} = -\,a_{13} \tag{40}$$

Thus,

$$a_{13}\,(\xi_{A3} + \xi_{D3}) = e \tag{41}$$

$$a_{13}\,(\eta_{A3} + \eta_{D3}) = d \tag{42}$$

Dividing Equation 41 by Equation 42 yields

$$\frac{\xi_{A3} + \xi_{D3}}{\eta_{A3} + \eta_{D3}} = \frac{e}{d} \tag{43}$$

Values of ξ_A, η_A, ξ_D and η_D which satisfy Equation 43 must be found in the dimensionless co-ordinate table (Fig. 3) for one value of $\eta' = y'_3$. From these values, a_{13} may be calculated using Equation 41 or 42.

The energy dissipated while the mass is moved from point 1 to 2 is

$$W = \int_1^2 \mu_1\,|N|\,ds + \int_0^d \mu_2\,|R|\,dy \tag{44}$$

where ds is an element of length along the cam path given by,

$$\begin{aligned} ds &= (dx^2 + dy^2)^{1/2} \\ &= a[1 + (\eta')^2]^{1/2} d\xi \\ &= a[1 + (\eta')^2]^{1/2}\,(\eta'')^{-1}\,d(\eta') \end{aligned} \tag{45}$$

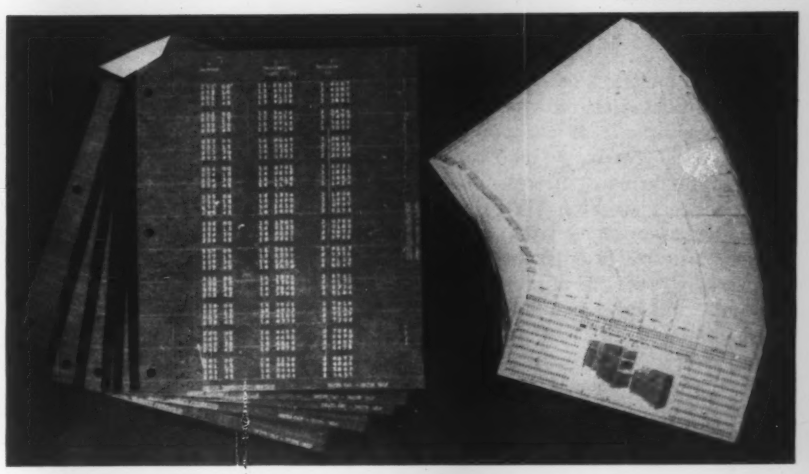


Fig. 9 — Cam co-ordinate computations showing punched cards and data prints for shop use.

The element dy can be expressed (see Equation 14) as

$$dy = a \frac{\eta'}{\eta''} d(\eta') \tag{46}$$

Therefore,

$$W = \int_{\eta_1'}^{\eta_3'} \frac{a}{\eta''} \left\{ \mu_1 N \left[1 + (\eta')^2\right]^{1/2} + \mu_2 |R| \eta' \right\} d(\eta') + \int_{\eta_3'}^{\eta_2'} \frac{a}{\eta''} \left\{ \mu_1 N \left[1 + (\eta')^2\right]^{1/2} + \mu_2 |R| \eta' \right\} d(\eta') \tag{47}$$

Neglecting gravity and assuming elastic impacts, it is seen that the straight-line path would dissipate no energy. However, since elastic impacts are not possible, and the corresponding large (theoretically infinite) loads are not permissible, it is necessary to utilize the constant-load cam paths in some form.

Constant-load cam-path segments, connected with a straight line, may be used to accelerate and decelerate the mass. This configuration is shown in Fig. 8 where the mass is accelerated from point 1 to 4, moves with constant velocity from point 4 to 5, and decelerates from point 5 to 2. The coordinates for accelerating and decelerating portions of this path would be computed from equations similar to Equations 34 through 37 while the straight line is represented by

$$y - y_4 = y_4'(x - x_4) \tag{48}$$

It is necessary that slope

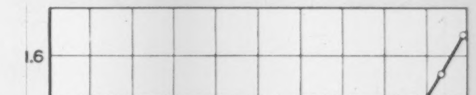
$$y_4' = \eta_4' = \eta_5'$$

and constants a_{14} and a_{52} be chosen such that the following equation is satisfied:

$$a_{52}\,\eta_{D5} + d - a_{14}\,\eta_{A4} = \eta_4'(a_{52}\,\xi_{D5} + e - a_{14}\,\xi_{A4}) \tag{49}$$

The energy dissipated in this instance can be computed from Equation 47 if the limit η_3' is replaced by η_4' or η_5' which are equal. It is seen, from substituting the expressions for R and a (Equations 4 and 10) into Equation 47, that the energy dissipated is independent of cam load N and will be a minimum for the curve having the maximum slope which is a minimum. The cam load is necessarily increased as the maximum slope is decreased by making the straight-line segment of the cam path longer. A limit is imposed on the cam load by the material of the cam path and follower for a given life of the cam follower. It is concluded that the minimum energy will be dissipated if the cams are designed up to this limit. The findings of J. J. Fleck[1] agree with this conclusion.

Digital Computer Techniques: Once the dimensionless cam co-ordinates (ξ, η) have been obtained on punched cards and the constants (a, b, and c) have been determined, it is a simple matter to compute the actual cam co-ordinates (x, y) by means of a digital computer. This type of problem is ideally suited to the digital computer, since the program is short and the number of repeated com-



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[1] J. J. Fleck—"Optimum Cam for the Vulcan Gun," General Electric Technical Information Series No. R56A0103, April 2, 1956, Fig. 3.

putations is large. For constant-load cams, the rate of computation using an IBM Type 650 Computer, is about 60 points per minute.

The co-ordinates of each point are punched out on individual cards, as shown in Fig. 9. These cards could be used directly as input to an automatic milling machine. With such a system, the possibility of human error, which is large in performing lengthy calculations and tabulating many numbers by hand, is minimized. In the absence of automatic milling machines, the cards may be machine tabulated in a form such that the tables may be reproduced directly by conventional tracing reproduction methods. A print of such a table is also shown in Fig. 9. Again, the necessity of making up tables by hand is eliminated. The digital computer also offers an extremely fast and accurate means of computing co-ordinates of cam curves which can be represented by analytic functions, allowing one to capitalize on the foregoing advantages.

Variable Cam Load: In the analysis, it was assumed that cam load N is constant over the cam length, and a dimensionless constant-load cam path was derived. For given mass, cam speed, and friction coefficients, actual cam paths can be calculated from the dimensionless cam paths by choosing the cam load N, thus fixing $a = mv^2/N$. Accelerating or decelerating cams may be specified in which cam load N and, thus, constant a, are different for different segments of the cam, or are continuously variable over the cam. Thus, a cam curve could be derived for any load distribution.

As an example, consider the parabolic cam load distribution shown in Fig. 7,

$$N = 2kmv^2 \, [1 + (y')^2]^{1/2} \tag{50}$$

Substituting Equation 50 into Equation 10 yields

$$a = \frac{1}{2k \, [1 + (y')^2]^{1/2}} \tag{51}$$

If Equation 51 is used to compute a_i for each interval of slope y_{i-1}' to y_i', the increments in the cam co-ordinates (x, y) may be obtained for each interval from

$$(\Delta x)_i = a_i \, (\xi_i - \xi_{i-1}) \tag{52}$$

$$(\Delta y)_i = a_i \, (\eta_i - \eta_{i-1}) \tag{53}$$

The co-ordinates may then be derived by summation of the increments,

$$x = \sum_i (\Delta x)_i \tag{54}$$

$$y = \sum_i (\Delta y)_i \tag{55}$$

Carrying through the above process of summation for $k = 0.42617$ in.$^{-1}$ and using the dimensionless cam co-ordinates for no friction gives the series of points plotted in Fig. 10. The original parabola, $y = 0.42617 \, x^2$, which has the load distribution given by Equation 50, is seen to pass through these points almost exactly. This establishes the validity of using the constant-load cam to derive cam curves when continuously variable cam loads are specified.

A Mechanisms Conference Paper

This article was presented as a paper at the Fourth Conference on Mechanisms, Purdue University, October 14-15, 1957. These Conferences are cosponsored by the Purdue School of Mechanical Engineering and MACHINE DESIGN.

Transactions containing the 13 papers (104 pages) presented at the Conference are available at $2.00 each from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

The Fifth Conference on Mechanisms will be held at Purdue University, Lafayette, Ind., October 13 and 14, 1958.

Tips and Techniques

Evaluation of Derivatives

The derivatives of an algebraic equation at any point may be simply evaluated by synthetically dividing the equation by the numerical value of the point of evaluation. Each successive remainder will be the value of the corresponding derivative as given by the Taylor Series Expansion,

$$y(0) = y_0 + y'(0) + \frac{y''(0)}{2!} + \frac{y'''(0)}{3!} + \ldots$$

Using the equation $x^3 - 12.2x^2 + 7.45x + 42 = 0$ as an example, it is desired to evaluate three derivatives at $x = 12$. By synthetic division,

$$\begin{array}{rl}
 & 1 - 12.2 + 7.45 + 42 \\
(12) & \quad + 12.0 - 2.40 + 60.6 \\
\hline
 & 1 - 0.2 + 5.05 + (103) = R \\
(12) & \quad + 12.0 + 142.00 \\
\hline
 & 1 + 11.8 + (147) = R' \\
(12) & \quad + 12.0 \\
\hline
 & 1 + (23.8) = R'' \\
 & (1) = R'''
\end{array}$$

This yields values for the derivatives of $y'_{(12)} = R'1! = 147$, $y''_{(12)} = R''2! = 47.6$; and $y'''_{(12)} = R''' \, 3! = 6$.—BARRY J. BARON, *Ford Instrument Co., Long Island City, N. Y.*

Coefficient method for determining

Reactions and Bending Moments in Beams

of two and three equal spans

By RICHARD H. FENG
Stress Analyst
Worthington Corp.
Harrison, N. J.

WHEN shafts or beams simply supported at more than two points are subjected to various types of loading, such as uniform, concentrated, or combinations of both, the bending moment at any point along the beam is usually difficult to determine. Calculation of bending moments and reactions for these continuous beams necessarily involves the three-moment equation or other equally cumbersome mathematical analysis.

This article presents a graphical method for determining reactions and bending moments in beams of two or three equal spans. It reduces the possibility of mathematical error and provides quick, accurate solutions to these problems.

The "coefficient method" presented here simply requires that a reaction or moment coefficient for each loading condition be read from appropriate curves and multiplied by given problem conditions to obtain the actual reaction or bending moment. For conditions of combined types of loading, the method of superposition is applied. The combined loading is broken down into separate loadings and the individual reactions of these are obtained as outlined in Steps 1, 2, and 3 of the Example. Results, using the law of superposition, are added algebraically to obtain a total reaction. For example, a reaction resulting from a combination of concentrated loads and uniformly distributed load is simply $R = \Sigma C_R P + \Sigma C_R w L$.

Fig. 1 through 9 show moment and reaction coefficients for two and three-equal-span beams under particular types of load conditions. Table 1 is a general summary of loading conditions and corresponding curves. Use of these coefficient curves is demonstrated in detail in the accompanying Example. Note that the method produces an average variation from the analytical solution of less than 1 per cent for reactions and less than 2 per cent for bending moments.

Nomenclature

b = Length of overhang, ft
C_M = Moment coefficient
C_R = Reaction coefficient
C_{MP} = Moment coefficient at point of load
C_{MR} = Moment coefficient at reaction
I = Moment of inertia of beam cross section
L = Span length, ft
M = Bending moment, lb-ft
P = Load, lb
R = Reaction, lb
w = Uniformly distributed load, lb per ft

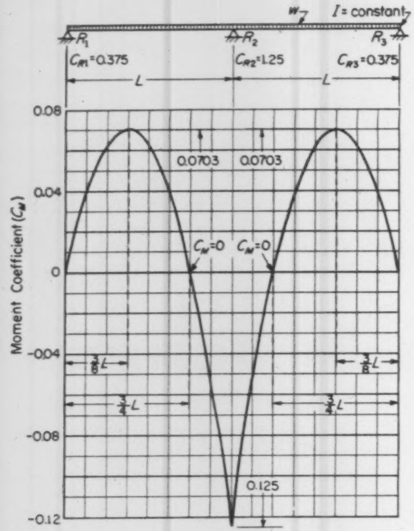


Fig. 1—Reaction and moment coefficients for a uniformly loaded beam with three supports. Reaction coefficients, shown at reaction points on the beam, are single valued. Intersection of a line projected from any point on the beam with the C_M curve gives value of C_M for that point. Reaction is $R=C_R\ wL$ and moment is $M=C_M\ w\ L^2$

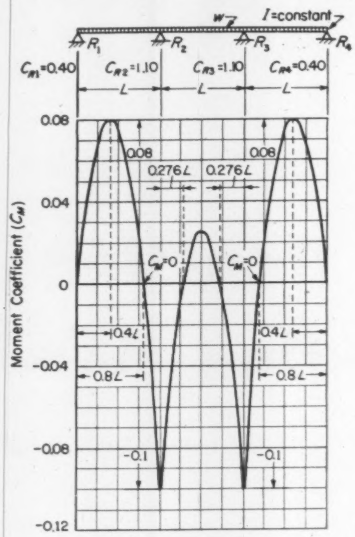


Fig. 2—Reaction and moment coefficients for a uniformly loaded beam with four supports. Single-valued reaction coefficients are shown at points of support. Reactions and moments are found in a manner similar to that for a two-span beam

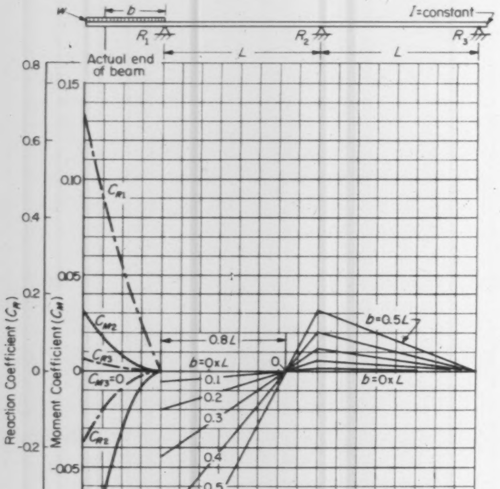


Fig. 3—Reaction and moment coefficients for a two-span beam with one uniformly loaded overhanging end. Effects of uniform load on reactions and moments at R_1, R_2, and R_3 are given by coefficients obtained from the C_R and C_M curves as outlined in Steps 2 and 5 of the Example. Reaction is $R=C_R\ w\ L$ and moment is $M=C_M\ w\ L^2$

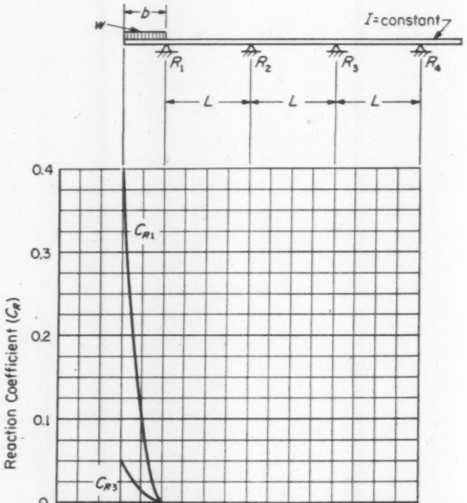


Fig. 4—Reaction coefficients for a three-span beam with one uniformly loaded overhanging end. Moment coefficients are shown in Fig. 5

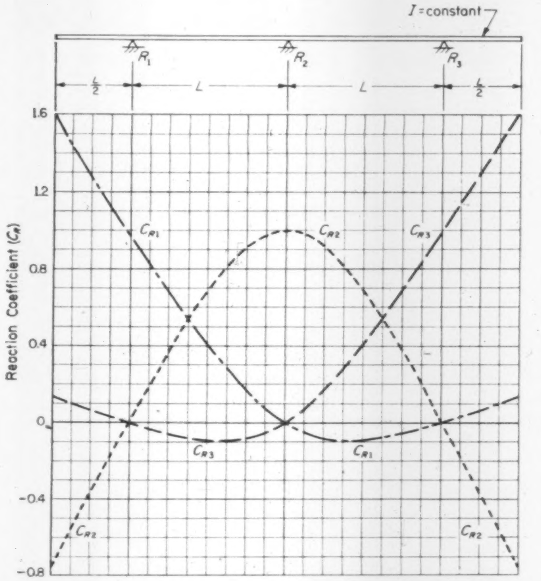


Fig. 6—Reaction coefficients for a two-span beam with two overhanging ends and subjected to a concentrated load at any point. Intersections of a line from the point of load with curves C_{R1}, C_{R2}, and C_{R3} give reaction coefficients for the effects of the load at points of support. Magnitude of reaction is given by $R = C_R P$

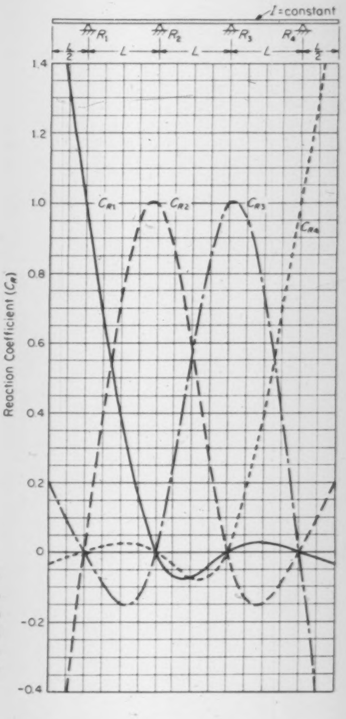


Fig. 7—Reaction coefficients for a three-span beam with two overhanging ends and subjected to a concentrated load at any point on the beam

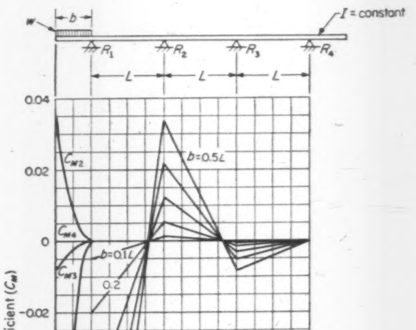


Fig. 5—Moment coefficients for a three-span beam with one uniformly loaded overhanging end. Reaction coefficients are shown in Fig. 4

Table 1—Guide to Coefficient-Chart Use

Operation	Two-Span Beam	Three-Span Beam
Finding Reactions		
A. Uniform load	Fig. 1	Fig. 2
B. Overhung uniform load	Fig. 3	Fig. 4
C. Concentrated load	Fig. 6	Fig. 7
Finding Moments		
D. Uniform load Moment at any point	Fig. 1	Fig. 2
E. Overhung uniform load Moment at reactions and at any point on the beam	Fig. 3	Fig. 5
F. Concentrated load Moment at reactions due to load (dashed curves)	Fig. 8	Fig. 9
G. Concentrated load Moment at load (solid curves)	Fig. 8	Fig. 9
H. Concentrated load Moment at any point	Calculate or find graphically as shown in Step 9 of the Example	

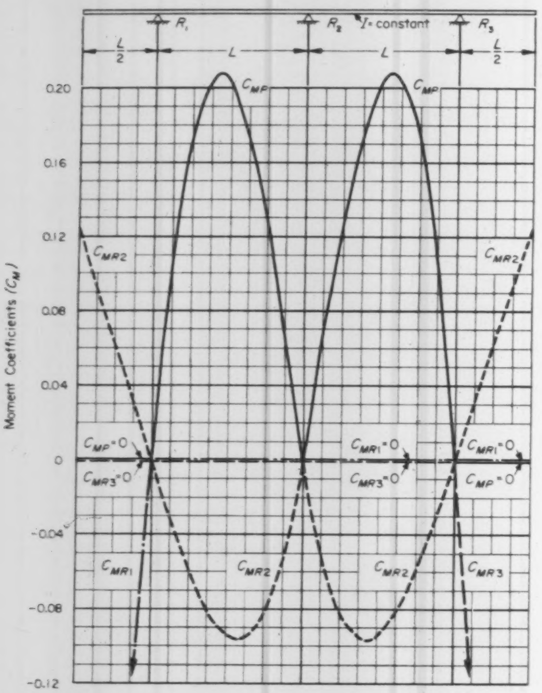


Fig. 8—Moment coefficients for a two-span beam with two overhanging ends and subjected to a concentrated load at any point. Effects of a concentrated load on moments at R_1, R_2, and R_3 are calculated from C_M values obtained from dashed-line curves at intersections of a line projected from point of load with curves. Intersections with C_{MP} curves give C_M for moment at point of load. Magnitude of moment is $M = C_M PL$

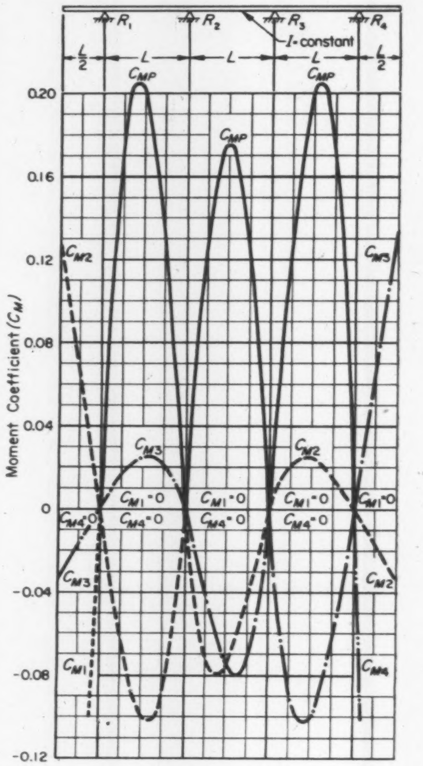
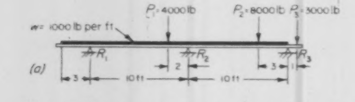


Fig. 9—Moment coefficients for a three-span beam with two overhanging ends and subjected to a concentrated load at any point

Example

Find the reactions, bending moments at the supports, and maximum bending moment of the beam shown in sketch *a*.



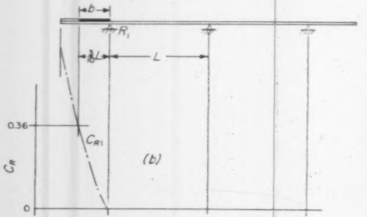
The following steps demonstrate the procedure, and results are collected and summarized in the accompanying table.

Procedure for Finding Reactions

Step 1: Find the effects of uniform load w between R_1 and R_3 on R_1, R_2, and R_3 (Operation A, Table 1). Use reaction coefficients shown in Fig. 1. For example, $R_1 = C_{R1}\,w\,L = 0.375\,(1000)(10) = 3750$ lb.

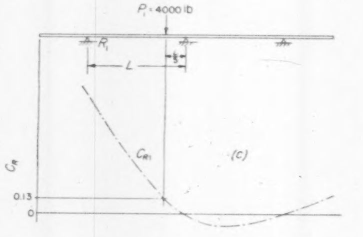
Step 2: Find the effects of the uniform load of the overhang on R_1, R_2, and R_3 (Operation B). Locate end of overhang as a fraction (3/10) of span length L in Fig. 3. Project a line from the end of the overhang and read reaction coefficients at intersections with curves C_{R1}, C_{R2}, and C_{R3}. Sketch *b*, for example, shows the solution for C_{R1}. Reaction $R_1 = C_{R1}\,w\,L = 0.36\,(1000)\,(10) = 3600$ lb. Effects at other two reactions are found in a similar way.

Step 3: Find the effects of concentrated loads P_1, P_2, and P_3 on R_1, R_2, and R_3 (Operation C). Locate a given load P as a fraction of span length L in Fig. 6. Intersections of a line projected from the point of load with curves C_{R1}, C_{R2}, and C_{R3} give reaction coefficients. For example, $P_1 = 4000$ lb is located on the span in sketch c, and C_{R1} is read. Reaction $R_1 = C_{R1}\,P = 0.13\,(4000) = 520$ lb. In similar fashion, the remaining effects upon R_2 and R_3 are found. This process is repeated for loads P_2 and P_3.



Procedure for Finding Moments

Step 4: Find the effect of uniform load w on the moments at R_1, R_2, and R_3 (Operation D). Moment coefficients are determined from intersection of lines projected from supports with C_M curve in Fig. 1. At R_2, for example, $C_{M2} = -0.125$. Moment $M = C_{M2}\,w\,L^2 = -0.125\,(1000)\,(10)^2 = -12{,}500$ lb-ft. Fig. 1, of course, is also used to determine C_M, due to a uniform load, for any point along the beam. Thus, it is also used to find the moments, due to a uniform load, at points of concentrated load.



Step 5: Find the effect of the uniform load of the overhang on the moments at R_1, R_2, and R_3 (Operation E). Locate end of overhang as a fraction of span length L in Fig. 3. Read moment coefficients at intersections of projected line from end of overhang with C_M curves. At R_1, for example, C_{M1} =

Reactions for Sample Problem

Reaction Location	Cause of Reaction and Magnitude (1000 lb)					Total Reaction (1000 lb) (Graphical)	Total Reaction (1000 lb) (Computed)	Variation in Methods (per cent)
	Uniform Load w Between R_1 and R_3 (Step 1)	Uniform Load of Overhang (Step 2)	Concentrated Load P_1 (Step 3)	P_2 (Step 3)	P_3 (Step 3)			
R_1	$+0.375\ (1)(10)$ $=+3.75$	$+0.36\ (1)(10)$ $=+3.60$	$+0.13\ (4)$ $=+0.52$	$-0.07\ (8)$ $=-0.56$	$+0.03\ (3)$ $=+0.09$	+ 7.40	+ 7.355	+0.61
R_2	$+1.25\ (1)(10)$ $=+12.50$	$-0.07\ (1)(10)$ $=-0.70$	$+0.95\ (4)$ $=+3.80$	$+0.44\ (8)$ $=+3.52$	$-0.15\ (3)$ $=-0.45$	+18.67	+18.640	+0.16
R_3	$+0.375\ (1)(10)$ $=+3.75$	$+0.01\ (1)(10)$ $=+0.10$	$-0.07\ (4)$ $=-0.28$	$+0.62\ (8)$ $=+4.96$	$+1.12\ (3)$ $=+3.36$	+11.89	+12.005	−0.95

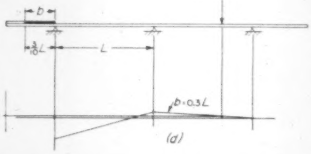
Moments for Sample Problem

Moment Location	Cause of Moment and Magnitude (1000 lb-ft)					Total Moment (1000 lb) (Graphical)	Total Moment (1000 lb) (Computed)	Variation in Methods (per cent)
	Uniform Load w Between R_1 and R_3 (Step 4)	Uniform Load of Overhang (Step 5)	Concentrated Load P_1 (Step 7)	P_2 (Step 7)	P_3 (Step 7)			
R_1	0	$-0.045\ (1)(10)^2$ $=-4.50$	0	0	0	− 4.50	− 4.50	0
R_2	$-0.125\ (1)(10)^2$ $=-12.50$	$+0.011\ (1)(10)^2$ $=+1.10$	$-0.072\ (4)(10)$ $=-2.88$	$-0.068\ (8)(10)$ $=-5.44$	$+0.025\ (3)(10)$ $=+0.75$	−18.97	−18.95	+0.105
R_3	0	0	0	0	$-0.1\ (3)(10)$ $=-3.00$	− 3.00	− 3.00	0
	Uniform Load w Between P_1 and P_3							
P_1	(Step 4) $-0.020\ (1)(10)^2$ $=-2.00$	(Step 6) 0	(Step 8) $+0.103\ (4)(10)$ $=+4.12$	(Step 9) $-0.054\ (8)(10)$ $=-4.32$	(Step 9) $+0.019\ (3)(10)$ $=+0.57$	− 1.63	− 1.66	−1.8
P_2	(Step 4) $+0.067\ (1)(10)^2$ $=+6.70$	(Step 6) $+0.004\ (1)(10)^2$ $=+0.40$	(Step 9) $-0.022\ (4)(10)$ $=-0.88$	(Step 8) $+0.19\ (8)(10)$ $=+15.20$	(Step 9) $-0.062\ (3)(10)$ $=-1.86$	+19.56	+19.50	+0.31
P_3	(Step 4) 0	(Step 6) 0	(Step 9) 0	(Step 9) 0	(Step 8) 0	0	0	0

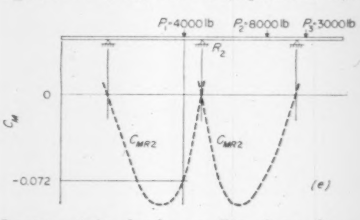
-0.045. Moment $M = C_{M1}\, w\, L^2 = -0.045\ (1000)\ (10)^2 = -4500$ lb-ft.

Step 6: Find the effect of the uniform load of the overhang on the moment at any point on the beam (Operation E). Project a line from the point on the beam in Fig. 3 to intersect the appropriate b/L curve. For example, as shown in sketch *d*, a line projected from point of load P_2 intersects the $b = 0.3L$ curve at $C_M = 0.004$. Moment $M = C_M\, w\, L^2 = 0.004\ (1000)(10)^2 = 400$ lb-ft.

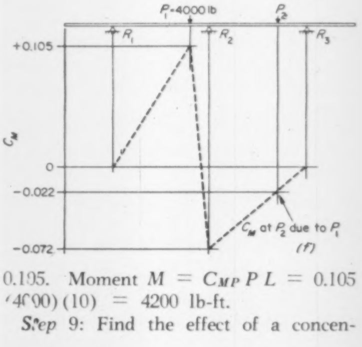
Step 7: Find the effects of concentrated loads, P_1, P_2, and P_3 on the moments at R_1, R_2, and R_3 (Operation F). Locate given loads on Fig. 8 as fractions of span length L. Intersection of a line projected from a point of load with C_{MR} curves (dashed lines) gives C_M values at the supports due to the load. For example, sketch *e*, the effect of load P_1 on the moment at R_2 is $C_{MR2} = -0.072$. Moment $M = C_{MR2}\, P\, L = -0.072\ (4000)(10) = -2880$ lb-ft.



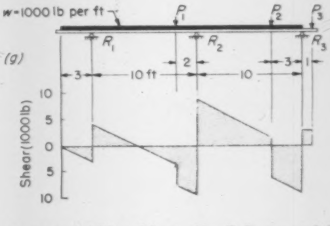
Step 8: Find the effects of concentrated loads P_1, P_2, and P_3 on the moments at P_1, P_2, and P_3 (Operation G).



Locate given loads on Fig. 8 as fractions of span length L. Intersection of a line projected from a point of load with the C_{MP} curves (solid lines) gives C_M values at the points of load due to the load. For example, the effect of load P_1 on the moment at P_1 is $C_{MP} = 0.105$. Moment $M = C_{MP}\, P\, L = 0.105\ (4000)(10) = 4200$ lb-ft.



Step 9: Find the effect of a concentracted load P_1, for example, on the moment at any point on the beam (Operation H). Locate the given load on Fig. 3 as a fraction of span length L. Determine C_M values due to the load for each support and for the point of load according to Steps 7 and 8, respectively. Locate these values (displaced laterally from the appropriate curves) directly under R_1, R_2, R_3, and P_1. Connect the points. For example, sketch *f* shows C_M values at R_1, R_2, R_3, and P_1 all due to P_1. Intersection of a line from any point on the beam with a line joining the C_M values gives the C_M at that point. C_M at P_2 due to P_1 is -0.022. $M = C_M\, P\, L = -0.022\ (4000)(10) = -880$ lb-ft.



Step 10: To find the maximum bending moment, construct a shear diagram, sketch *g*, using given loads and values obtained according to Steps 1 through 3. Locate the point or points where shear is zero and determine bending moment.

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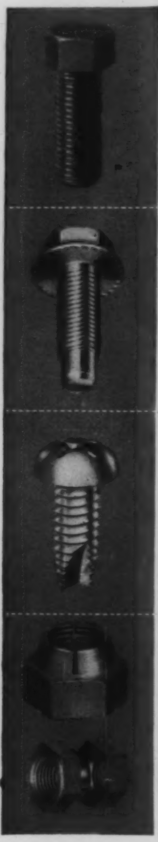

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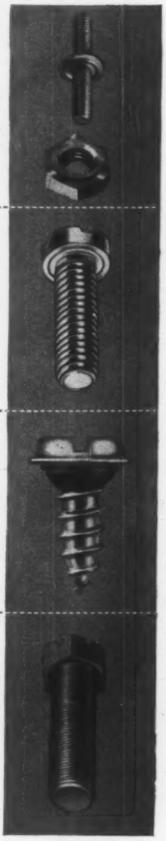

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DESIGN ABSTRACTS

mechanical

Basic Gages for Automatic Machine Control

J. W. Hooper, Pratt & Whitney Co. Inc.

The author arbitrarily defines automatic machine control as a condition whereby material is manufactured by a piece of machinery with suitable equipment to measure the product while it is being manufactured and provide corrections to keep tolerances within limits. Basic principles of gaging, gaging accuracies, and types of gaging are discussed with reference to the definition.

ASME paper 58-AUT-6, from ASME-AIEE-IRE Joint Conference on Automatic Techniques, Detroit, April, 1958; 4 pp.

Dynamic Loading Of Spur Gear Teeth

A. Y. Attia, Cairo, Egypt

This paper presents results of strain-gage investigations conducted on steel spur gears to measure instantaneous load on the tooth under static conditions as well as dynamic conditions of operation.

ASME paper 58-SA-32, from Semiannual Meeting, Detroit, June, 1958; 7 pp.

Elements of Joint Design For Welding

K. H. Koopman, Welding Research Council

Proper joint design is important to fabrication by welding because it helps control distortion, minimizes residual stresses, facilitates good workmanship, reduces welding costs, and produces greater reliability. It is shown how fabrication and quality control techniques should be introduced into the design at an early stage to insure the advantages mentioned. Included is a discussion on design of joints for fusion welding by any of the arc or gas processes. Techniques apply to manual and machine welding.

AWS National Spring Meeting, St. Louis, April, 1958; 10 pp.

The Pin

M. J. Schilhansl, Brown University

Stress and strain of different types of pins are analyzed in more detail than the conventional consideration of shear strength offers. Analysis reveals that there are cases in which shear strength is not the criterion for proper selection of pin size and type. Several types of pins are compared, and advantages of a spirally coiled pin for static and fluctuating loads are pointed out.

ASME paper 58-SA-23, from 1958 Semiannual Meeting, Detroit; 7 pp.

Structural Error Analysis in Plane Kinematic Synthesis

Ferdinand Freudenstein, Columbia University

Methods are developed for estimating and obtaining minimum structural error in the approximate synthesis of plane, function, or path-generating mechanisms. Application to a four-bar function-generating mechanism is worked out with the aid of a large-scale digital computer used in the manner of a servo loop.

ASME paper 58-SA-12, from 1958 Semiannual Meeting, Detroit; 7 pp.

Thermal Stress In Ductile Materials

B. F. Langer, Westinghouse Electric Corp.

Methods are proposed for the application of strain-cycling data to practical problems involving thermal stress. Subjects considered include multiaxial stress conditions, combined steady and alternating stress, and cumulative damage. Design methods proposed constitute safe approximations which are consistent with experimental data available.

AWS paper, "Design Values for Thermal Stress in Ductile Materials," from AWS National Spring Meeting, St. Louis, April, 1958; 36 pp.

Integration of Mechanical and Electric Design in Servos

Glenn G. Ertell, General Electric Co.

Quality of a servo system depends on the degree of understanding and attention given to the interaction between mechanical and electrical components in the system. Servomechanism theory and criteria on which it is based are discussed. Mechanical and electrical design integration is covered by example.

ASME paper 58-MD-12, from 1958 Design Engineering Conference, Chicago; 4 pp.

Design and Development Of a Supercharger

R. C. Reisweber and J. R. Shields, Elliott Co.; and J. W. Glessner, Solar Aircraft Co.

Features of mechanical and thermodynamic design of an axial-flow supercharger for a pressure-fired boiler are presented. The 11-stage axial compressor is designed to supply air at 40,000 cfm at a pressure ratio of 4.5. Power required is furnished by integrally cased two-stage gas turbine. Thermodynamic performance of the supercharger is presented.

ASME paper 58-SA-25, "Design and Development of a Supercharger for a Pressure-Fired Boiler," from 1958 Semiannual Meeting, Detroit, 9 pp.

Design of Helical Springs

R. T. Hinkle and T. E. Morse, Michigan State University

In the design of helical springs where load, deflection, allowable stress, and material are specified, there are an infinite number of solutions. In this paper, equations and graphs are presented for the selection of a spring index which results in a spring of minimum weight, volume, or length. Equations and graphs are included for the selection of the spring index which satisfy additional requirements of fixed spring diameters.

ASME paper 58-SA-9, "Design of Helical Springs for Minimum Weight, Volume, and Length," from 1958 Semiannual Meeting, Detroit, 4 pp.

Behavior of Welded Corner Connections

J. W. Fisher, G. C. Driscoll Jr., and F. W. Schultz Jr., Lehigh University

A report on the second phase of a program on welded continuous frames and their components. Purpose of the test was to determine whether corner connections of different types would show satisfactory performance when used in structures designed by either plastic or elastic analysis. Problems discussed include strength, stiffness, rotation capacity, and economy of fabrication. Effects of size of a member on behavior of the connection is covered.

AWS National Spring Meeting, St. Louis, April, 1958; 49 pp.

techniques

Temperature Measurement

W. M. Rohsenow and R. J. Nickerson, Massachusetts Institute of Technology

Quality of heat transfer data depends to a large extent on the accuracy of temperature measurements. This paper describes some common methods of temperature measurement and estimates the precision attainable with these devices. Calibration of thermometers is discussed, and problems of surface, fluid, and bulk temperature measurements are solved in specific examples.

IRE Transactions on Aeronautical and Navigational Electronics, *Vol. ANE-5, No. 1; page 52.*

Listening—The Missing Link In Communication

C. J. Dover, General Electric Co.

Recent research findings point up the shortcomings in a neglected area of industrial communication. These widespread deficiencies in listening skill carry with them an extremely high and needless price tag in both time and dollars. Reasons for listening deficiencies are analyzed, and corrective measures for improving listening skill are suggested.

General Electric Review, *May, 1958, page 7.*

Automatic Engineering Through Computers

R. W. Ferguson, Westinghouse Electric Corp.

The most common result of adapting computers to engineering projects has been the extension of manpower to cope with increased design problems. Characteristics of computers and application of computers to product design are outlined to show the over-all program required to arrive at a design which meets specifications.

AIEE paper CP58-588, from AIEE-ASME-IRE Joint Conference on Automatic Techniques, Detroit, April, 1958; 9 pp.

Storing and Retrieving Coded Mechanical Engineering Data

Edna Genevieve Gilbo, Custom Mechanical Parts Mfg.

A firsthand account of how electronic data-processing machines and coded data fulfill industry's need for an economic and efficient reference system. The system makes readily available necessary documentary and product-file information needed for design, research development, and standardization decisions.

ASME paper 58-SA-6, "A Blueprint for the Storage and Retrieving of Coded Mechanical Engineering Data," from 1958 Semiannual Meeting, Detroit, 5 pp.

The Information Center Of Tomorrow

Allen Kent and J. W. Perry, Western Reserve University

Various improved methods and new devices for the analysis, storage, selection, and retrieval of information have been developed for improving effective availability of recorded knowledge. Use of new devices for searching and correlating scientific and technical literature is covered.

ASME paper 58-MD-13, 1958 Design Engineering Conference, Chicago; 12 pp.

Facets of the Technical Information Problem

C. P. Bourne and D. C. Englebart

A mass of technical information has been accumulated at a rate that has far outstripped means for making it available to those working in science and engineering. The many concepts that must be considered in fashioning an integrated technical information system and the needs served by it are appraised. Complexities surrounding any approach to such a system are suggested by questions given here.

SRI Journal, *Vol. 2, No. 1, 1958, page 2.*

A Central Catalog File Saves Engineering Time and Money

James L. Dykes, E. I. du Pont de Nemours & Co.

Experience indicates that a central catalog file saves time of technically trained personnel and money for the company by reducing loss time of engineers. Discussion of catalogs and files answers these questions: Why do engineers need catalogs, what are advantages of a central catalog file, how is a new catalog file created and operated, and what does it cost?

ASME paper 58-MD-14, 1958 Design Engineering Conference, Chicago, 5 pp.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 25 cents to members, 50 cents to nonmembers.

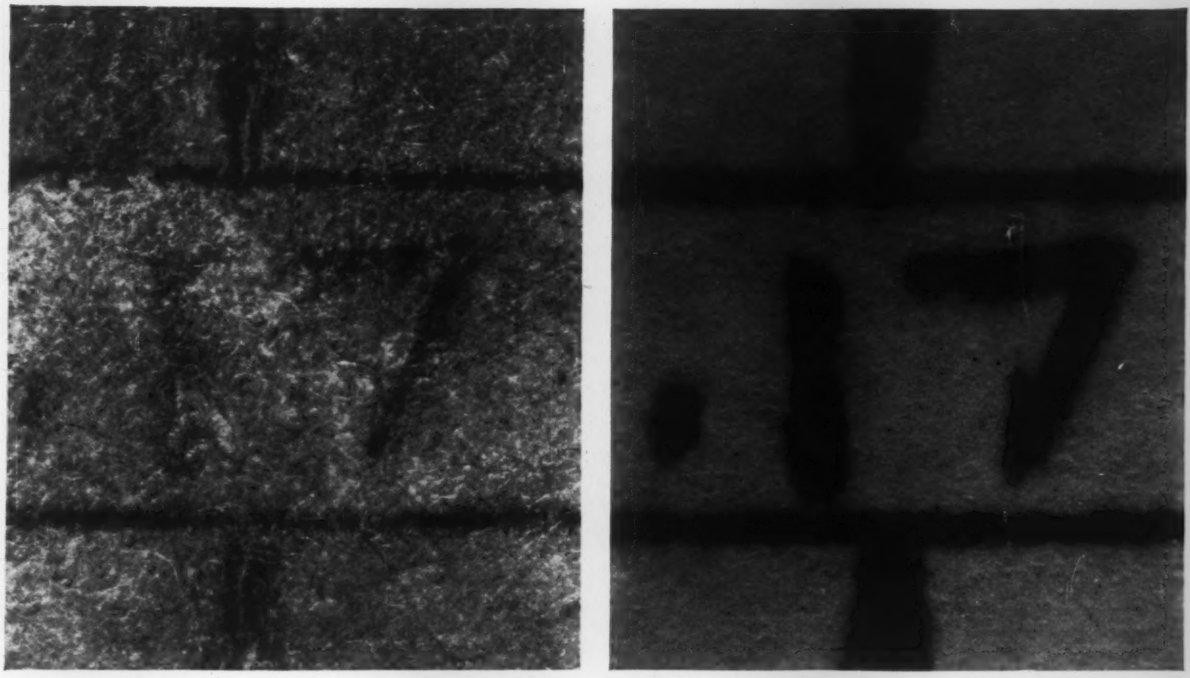
AWS—American Welding Society Inc., 33 West 39th St., New York 18, N. Y.

IRE—The Institute of Radio Engineers, 1 East 79th St., New York 31, N. Y.

General Electric Review—General Electric Co., Schenectady 5, N. Y.

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.

SRI Journal—Stanford Research Institute, Menlo Park, Calif.



These photomicrographs show effects of identical handling on (l.) a pencil drawing and (r.) an Autopositive Paper intermediate made from same drawing

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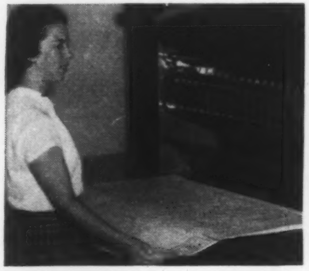

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Circle 466 on Page 19

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card — page 19

Rubber-Asbestos Gasketing

Features of Kaobestos rubber-asbestos gasketing are pointed up in folder. Material is offered with GRS, neoprene, and Buna N grades of rubber. F. D. Farnam Co., 4940 W. Flournoy St., Chicago 44, Ill. J

Circle 561 on Page 19

Stainless Steel

Relative corrosion resistance of 34 grades of stainless steels is comprehensively discussed and graphically shown on file-size card identified as Sec. A, No. 8. Peter A. Frasse & Co., 17 Grand St., New York 13, N. Y. D

Circle 562 on Page 19

Magnetic Equipment

"Magnetic Ideas from Eriez" is title of booklet describing the varied uses of permanent, nonelectric magnetism in modern materials handling and separation equipment. Sections cover magnetic separators, magnetic automation units, and vibratory magnetic feeders. 48 pages. Eriez Mfg. Co., 70D Magnet Dr., Erie, Pa. F

Circle 563 on Page 19

Rotary Torque Actuators

Catalog 26282 lists 26 standard styles and 312 modifications of Rotac rotary oscillating torque actuators for pull, push, lift, lower, or roll over functions. Output torques range from 100 to 220,000 lb-in. Units are air, oil, or fluid-operated at up to 1000 psi pressures. Ex-Cell-O Corp., 945 E. Sater St., Greenville, Ohio. G

Circle 564 on Page 19

Bronze Bushings & Bearings

Catalog 580 lists 248 additional sizes of standard stock cast bronze bushings and bearings, and fully machined bars. Special bearings include four graphited types. 28 pages. Buckeye Brass & Mfg. Co., 6410 Hawthorne Ave., Cleveland 3, Ohio. F

Circle 565 on Page 19

Bearing Locknut

Self-locking Bearhug locknut for retaining antifriction bearings on spindles and shafts is subject of bulletin. It incorporates a locking fiber insert in its design. Sizes are tabulated. 4 pages. Bearing Locknut & Machine Co., 4 Union Ave., Irvington, N. J. D

Circle 566 on Page 19

Temperature Controls

Wide variety of both local-mounted and remote bulb temperature controls are specified in Catalog 400, including general purpose, dual switch, explosionproof, and indicating types. 8 pages. United Electric Controls Co., 79 School St., Watertown 72, Mass. B

Circle 567 on Page 19

Semiflexible Transmission Line

Spir-O-line semiflexible aluminum-sheathed transmission line is an air dielectric coaxial type developed to replace sectional air or solid dielectric lines. It has excellent broadband characteristics. General information and photos of Spir-O-line are provided in Catalog 439. 10 pages. Prodelin Inc., 307 Bergen Ave., Kearny, N. J. D

Circle 568 on Page 19

Synchro & Servo Motors

Electrical and mechanical characteristics for a wide range of synchro and servo motors, linear transformers, and motor generators are presented in catalog. 20 pages. Clifton Precision Products Co., 9014 W. Chester Pike, Upper Darby, Pa. E

Circle 569 on Page 19

Variable Transformers

Powerstat variable transformers deliver continuously adjustable voltage from ac power lines. Single units and ganged assemblies are offered for use on 120, 240, or 480 v. Ratings range from 2.6 to 8.5 amp. Details are given in Data Sheet SE-L2581. 4 pages. Superior Electric Co., Dept. EN, Bristol, Conn. B

Circle 570 on Page 19

Chemical Milling

Advantages and engineering applications of chemical milling and metal finishing are described both pictorially and graphically in brochure. Information also covers Dow and HAE processes, color anodizing, anodizing, and vacuum cadmium plating. 30 pages. Anadite, Inc., 10630 Sessler St., South Gate, Calif. L

Circle 571 on Page 19

Air Cylinders

Bulletin 103 on Series "a" 200-psi air cylinders provides technical data and mounting details on units with 1½ to 14-in. bores. Mo-Bar Hydraulic Sales, Inc., Crystal Lake, Ill. J

Circle 572 on Page 19

Solenoid Valves

Illustrations of many ASCO solenoid valves supplied for primary and secondary systems in pressurized water nuclear reactors are contained in folder. Specifications and application data are included. 4 pages. Automatic Switch Co., Florham Park, N. J. D

Circle 573 on Page 19

Tube Shields & Guards

Company's tube shielding and tube guard products for miniature and subminiature electron tubes are detailed in Folder 100. Mini-Shield holds any miniature tube in its socket with a grip that tightens against any force. 6 pages. Staver Co., 41-51 N. Saxon Ave., Bay Shore, N. Y. D

Circle 574 on Page 19

Analog Computer

Illustrated Brochure 393 on the Model MC-400 Desk-Side analog computer describes operational amplifiers and other standard and optional equipment. Instrument provides a complete, portable computer center. 8 pages. Mid-Century Instrumatic Corp., 611 Broadway, New York 12, N. Y. D

Circle 575 on Page 19

Snap-Action Switches

Information in Catalog 0158 on Unimax snap-acting switches covers general-purpose, high-sensitivity, environment-free, immersionproof, metal-cased, AN and JAN, direct-current, reset, appliance, miniature, and subminiature styles. 28 pages. W. L. Maxson Corp., Unimax Switch Div., Wallingford, Conn. B

Circle 576 on Page 19

Motors & Generators

The 1958 Application Guide on motors and generators provides data to simplify selection. Typical driven equipment, character of loads, and starting and running torques are charted. Also detailed is line of polyphase, single-phase and direct-current motors from 1/20 to 400 hp. 12 pages. Century Electric Co., 18th & Pine Streets, St. Louis 3, Mo. I

Circle 577 on Page 19

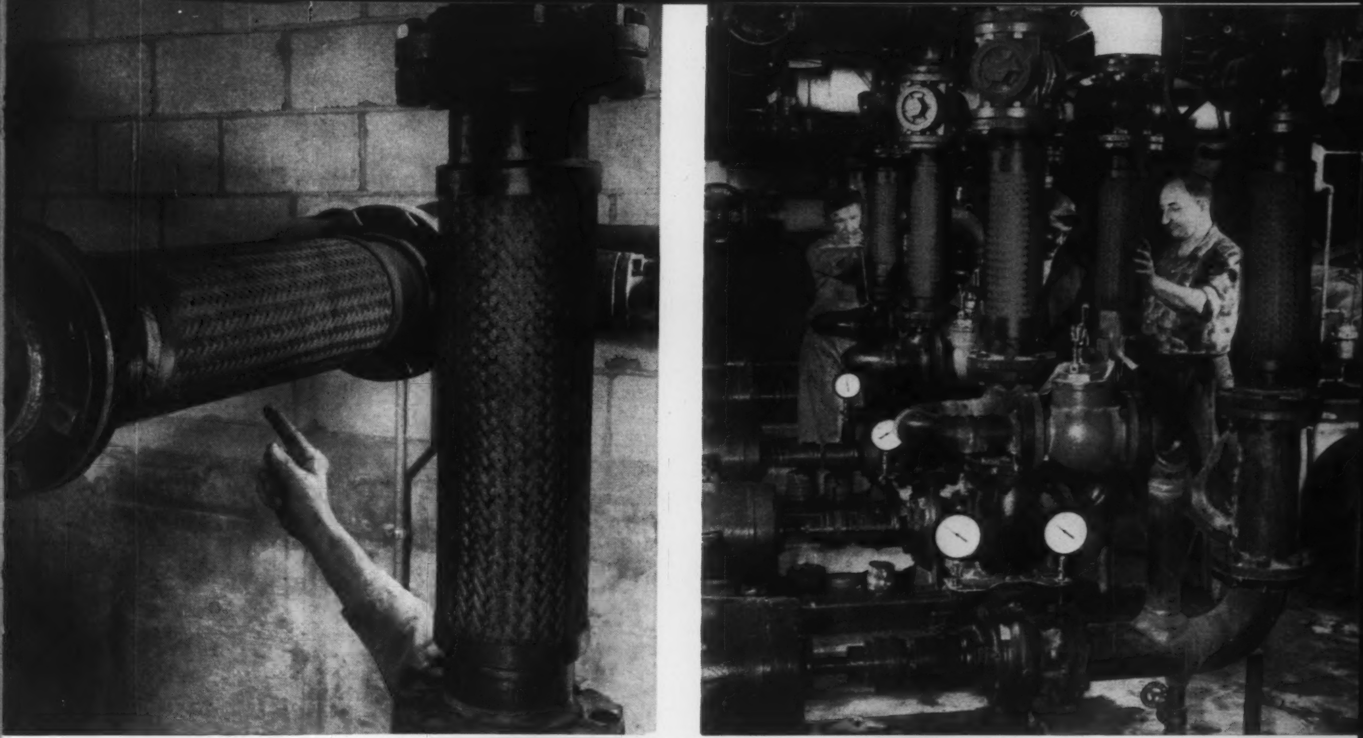
Precision Gears

Different types of UQ fine pitch precision gears are illustrated in Brochure 5811. Gears range from 300 to 24 diametral pitch and from 0.0625-in. diameter and up. An 11½-million-to-1 reduction gear train for sidereal clock and missile gear drives is shown. Western Gear Corp., Box 182, Lynwood, Calif. L

Circle 578 on Page 19

Blower-Compressor

The CycloBlower axial flow, positive displacement blower-compressor for pressure, vacuum, or combination service is latest addition to company's line. Its



PHOTOS PROVIDED through the courtesy of **GRAFLEX, INC.**, manufacturers of precision photographic, electronic and optical products, at the company's new multimillion-dollar Rochester, N. Y., plant.

New Flexpipe flexible bronze tubing isolates vibration, provides expansion joint for Graflex, Inc.

THE PROBLEM:

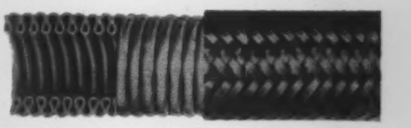
In a heating and air conditioning system, the temperature range of water and condensate varies over a 180°F. range. Some means were required to provide for expansion and contraction in the system without putting undue stress on rigid pipe and to confine the vibration to the compressors.

THE SOLUTION:

Use of new large-size (4″, 5″ and 6″ I.D.) American Flexpipe — flexible bronze tubing assemblies complete with end fittings.

Flexpipe connectors — in standard sizes — can solve tough problems for you, too, wherever air, gas, oil, steam or water must be conveyed, because Flexpipe:

- Has extreme flexibility that lessens chances of breakage and leakage from expansion and contraction.
- Needs little maintenance attention.
- Dampens noise, absorbs vibration, takes up movement, solves misalignment problems.
- Cuts installation costs (does away with time and material costs of rigid conduit requiring elbows, couplings, short runs of pipe, etc.).
- Makes installations quick and easy —especially in cramped quarters.



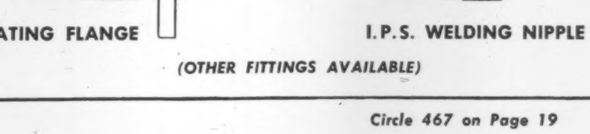
CONSTRUCTION: Inner hose corrugated for flexibility; wire braid over inner hose for added strength. Available in bronze, steel and stainless steel.

WHERE TO BUY:

Leading wholesaler distributors can provide you with information about Flexpipe in large sizes. These same distributors can show you samples and answer your questions about service applications for Flexpipe connectors in convenient standard sizes from ¾″ up to 16″ I.D. For the name and address of the distributor serving your area, or for more detailed information, write to: The American Brass Company, American Metal Hose Division, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

58167

TYPICAL FITTINGS FOR FLEXPIPE



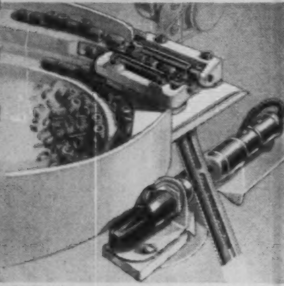
(OTHER FITTINGS AVAILABLE)

Flexpipe®

AN ANACONDA® PRODUCT

Circle 467 on Page 19

NOW, hopper-fed headless set screws AUTOMATE SUB ASSEMBLY!



CUT Operational Time 80% to 90%
CUT Floor Area
CUT Floor Waste from 30% to 0
CUT Worker Fatigue

The new Setko System can be used for almost any headless set screw application in sub or final assembly. All type points and most popular styles of set screws can be hopper fed.

This is what users have to say about Setko Hopper Feeding . . .

"Increased insertion rate of ¼-20 x ½ socket head set screw in shaft lock collar from 1200 a day by manual insertion to 2400 a day."

"Set Screw insertion in rotor was increased from 5600 to 9600 in an eight hour day. We get better quality insertions."

"Reduced rejects to almost zero. Increased insertion rates from 2000 to 4800 . . . Almost triple."

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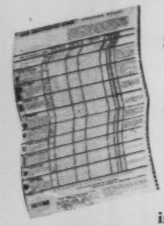

Shows how and where to use over 1,001 combinations for particular applications.

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Other Patents Pending
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construction features, applications and advantages are covered in Bulletin CB 157. 4 pages. U. S. Hoffman Machinery Corp., 105 Fourth Ave., New York 3, N. Y. D

Circle 579 on Page 19

Copper-Clad Laminates

Mechanical and electrical characteristics of four grades of copper-clad plastic laminates for electronic printed circuits are tabulated in Folder 8-1. Typical circuits are shown. 4 pages. Taylor Fibre Co., Norristown, Pa. E

Circle 580 on Page 19

Timers & Time Switches

Mark-Time timers and time switches for appliance and industrial applications are available in two-screw, center stud, and through panel mountings. Timing range is 60 sec to 12 hr, and rating is 28 amp, 120-240 v ac. Form BX-233 provides details. 4 pages. M. H. Rhodes, Inc., Hartford 6, Conn. B

Circle 581 on Page 19

Clutch-Brake Motors

Diehl-Ferguson integral high inertia clutch-brake motors for rapid start-stops and impulse applied loads are available with from ½ to 5 hp and with full load speeds to 1735 rpm. Bulletin 700 describes the whole line. 4 pages. Ferguson Machine Corp. of Indiana, 7818 Maplewood Industrial Court, St. Louis 17, Mo. I

Circle 582 on Page 19

Micro-Miniature Connectors

Specifications, diagrams, and general information on line of micro-miniature electrical connectors are available in illustrated Bulletin MM22. Connectors meet MIL-C-8384 specifications. 4 pages. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 583 on Page 19

Synchronous Timers

Easily interchangeable 1, 3, and 5-min timing units are offered in Bulletin 10336 synchronous motor-driven timers, subject of Catalog EN-33. Data on adjustable time intervals, ratings, and installation are offered. 6 pages. Cutler-Hammer, Inc., 315 N. Twelfth St., Milwaukee 1, Wis. K

Circle 584 on Page 19

Colloidal Dispersions

"The ABCs of Colloidal Dispersions" answers many questions about colloids with story, drawings, and pictures. It also lists technical bulletins available on the uses of colloidal graphite. 12 pages. Acheson Colloids Co., Port Huron, Mich. H

Circle 585 on Page 19

Plugs & Receptacles

Complete line of electrical plugs and receptacles in 30, 60, and 100-amp capacities; cord grips; and explosionproof

SHOP TIP

For an Easier Way to Remove Packing

Here is a rugged, flexible, hand-tool that "works around corners" for removing old packing from stuffing boxes. The picture above shows how Dura Hooks operate around obstructions. All steel — tempered steel corkscrew bit — made in 6 sizes — nominal in price.

DURA HOOKS

Ask your jobber—or write for DURA HOOK Bulletin No. MD-DH covering sizes and prices.

The PERFECT SEAL

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

Circle 468 on Page 19

Circle 469 on Page 19

fittings are listed in Catalog 2. Covered are 2, 3, 4, and 5-pole pin and sleeve receptacles and porcelain blocks. 76 pages. Ralco Mfg. Co., 123 N. Albany Ave., Chicago 12, Ill. I

Circle 586 on Page 19

Tool Steel Process

Company's tool steel process for hardening gears, pinions, wheels, and rolls is subject of Bulletin 352. Process converts wearing surfaces from a low carbon steel to a high carbon steel with tool steel properties. 6 pages. Tool Steel Gear & Pinion Co., Elmwood Place, Cincinnati 16, Ohio. G

Circle 587 on Page 19

Pancake Motors

Engineering information on enclosed pancake type motors is presented in Bulletin 2100. Flange type, air-gap design motors for space-cramped use are offered in 1 to 15-hp ratings. Specifications are given. 4 pages. Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 588 on Page 19

Electrical Connectors

A lighter and shorter version of the MS-E line of Cannon plugs is described in Catalog MS-E-3. New design affords 25 per cent reduction in length and 15 per cent in weight. All Type E plugs conforming to MIL-C-5015 are covered. 16 pages. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif. L

Circle 589 on Page 19

Pure Titanium

Engineering data on commercially-pure titanium given in illustrated bulletin include chemical, mechanical, and physical properties; table of corrosion resistance comparison with zirconium, tantalum, and type 316 stainless steel; and fabrication guidance. 8 pages. Mallory-Sharon Titanium Corp., Niles, Ohio. G

Circle 590 on Page 19

Headed Fasteners

"How to Specify Fasteners and Save" is title of technical bulletin which deals with designing for heading, designing for secondary operations, materials and their properties, drawings and specifications, and engineering service. 16 pages. Buffalo Bolt Co., North Tonawanda, N. Y. N

Circle 591 on Page 10

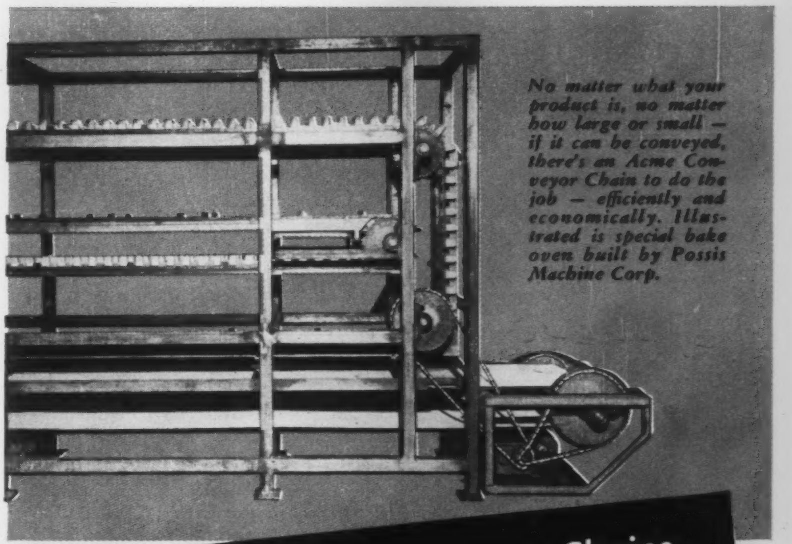
High Temperature Alloy

Chemical composition, physical properties, and mechanical properties are but a few of the data presented in Bulletin F-30,044 on Haynes Stellite Alloy No. 31. This is a cobalt-base casting alloy with superior high-temperature properties. 16 pages. Haynes Stellite Co., Kokomo, Ind. C

Circle 592 on Page 19

FHP Motors

The type R-29 electric motor is available in synchronous, induction, and hysteresis synchronous types, with speeds to 3600 rpm, and ratings from 1/30



No matter what your product is, no matter how large or small — if it can be conveyed, there's an Acme Conveyor Chain to do the job — efficiently and economically. Illustrated is special bake oven built by Possis Machine Corp.

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Circle 470 on Page 19

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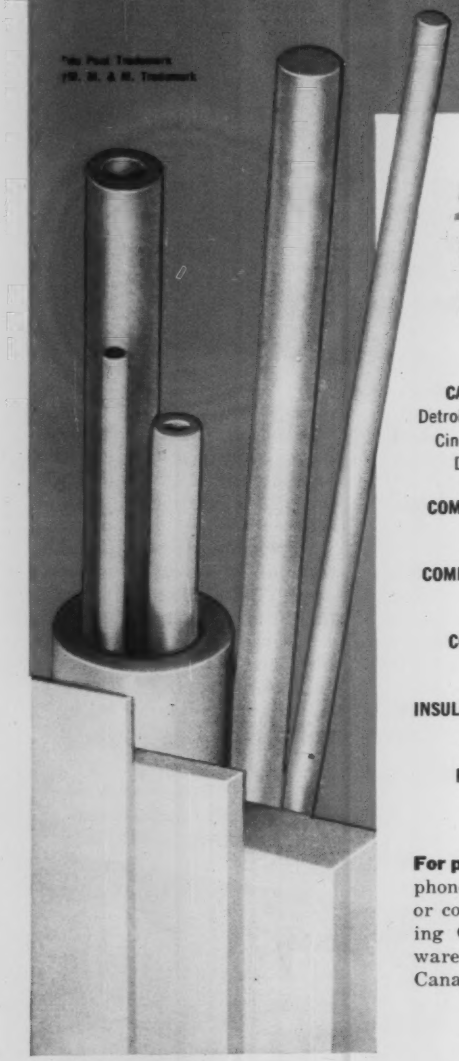

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Circle 471 on Page 19

to 1/175 hp, depending upon type. Full details of design and performance are given in Bulletin MO-3.9. 4 pages. National Pneumatic Co. and Holtzer-Cabot Div., 125 Amory St., Boston 19, Mass. B

Circle 593 on Page 19

Electric Clutches

I-T-E Electro Clutches are available in six basic designs with torque capacities from 1.8 through 13,000 lb-ft. Bulletin 6304-1A cites performance and typical applications of this clutch which provides instantaneous pushbutton or automatic programming of machine tools, drives, transmissions, and other shaft-driven machinery. 20 pages. I-T-E Circuit Breaker Co., 19th & Hamilton Streets, Philadelphia 30, Pa. C

Circle 594 on Page 19

Special Purpose Fasteners

Among the fasteners described in bulletin entitled, "Special-Purpose Fasteners," are Marsden lock nuts, automotive, and miscellaneous fasteners; Dardelet rivet bolts; high-strength bolts; two-fin flat-head bolts; a wide range of steel and aluminum nuts; and Safe-Line wire rope clamps. 16 pages. Lamson & Sessions Co., 5000 Tiedeman Rd., Cleveland, Ohio. G

Circle 595 on Page 19

Molded Nylon Parts

Typical nylon filled parts molded of Nylatron GS fortified with molybdenum disulphide are shown in illustrated Bulletin GS-1. Property data as well as application information in various industries are covered. National Polymer Products, Inc., 125 N. Fourth St., Reading, Pa. C

Circle 596 on Page 19

Wire & Cable Insulation

"Geon for Wire and Cable" is title of illustrated bulletin. Tabulated are various Geon plastics which meet Underwriters' Specifications, as well as properties of Geon plastics for primary and jacketing insulation. 12 pages. B. F. Goodrich Chemical Co., 3125 Euclid Ave., Cleveland 15, Ohio. F

Circle 597 on Page 19

Air Control Valves

Design and specification details as well as schematic drawings of typical circuits are included in 1958 Catalog entitled, "Air Control Valves." Thousands of types and sizes are detailed for practically every pneumatic control purpose. Price list supplements the catalogued information. 64 pages. Airmatic Valve, Inc., 7317 Associate Ave., Cleveland 9, Ohio. G

Circle 598 on Page 19

Flexible Gear Couplings

Revised Catalog C-5 on Flexible gear couplings provides details on bore sizes from $3/8$ to $12\frac{1}{2}$ in. with load capacities from 4 to 4000 hp per 100 rpm. Installation information, typical applications, and lubrication requirements are considered. 20 pages. Sier-Bath Gear &

Pump Co., 9254 Hudson Blvd., North Bergen, N. J. D

Circle 599 on Page 19

Welding Electrical Contacts

A flat or radius facing of contact material bonded to a metal backing comprises projection-welded "steelback" contacts typically used in aircraft circuit breakers and relays, motor starters, and auto switches. Over 100 sizes are listed in Technical Bulletin 501. 4 pages. Gibson Electric Co., Box 614, Delmont, Pa. G

Circle 600 on Page 19

Wire Cloth Strainers

"Engineer's Manual of Wire Cloth Strainer Design" explains various grades of wire cloth and covers mesh and wire sizes. Manual presents a step-by-step procedure of designing wire cloth strainers to meet special requirements. Michigan Wire Cloth Co., 2202 Howard, Detroit 16, Mich. H

Circle 601 on Page 19

Variable Speed Drives

Supplementary Catalog M-585, to be used in conjunction with earlier Catalog M-571, provides descriptive information on the new 400 Motodrives ranging in capacity from 7½ through 10 hp. 8 pages. Reeves Pulley Co., Columbus, Ind. J

Circle 602 on Page 19

Strip Steel Specialties

Booklet 6586 provides information concerning manufacture and end uses of a typical selection of Amerstrip cold rolled strip steel specialties. End uses include bandsaws, door-check springs, feeler gages, staple wire, rule steel, and safety shoe toe caps. 16 pages. United States Steel, American Steel & Wire Div., Rockefeller Bldg., 614 Superior Ave., Cleveland 13, Ohio. F

Circle 603 on Page 19

Distribution Switchboard

The Type DR low-voltage distribution switchboard which accepts any combination of six different types of protective devices is subject of Booklet GEA-6627. It discusses features, application, system selection, and guide-form specifications. 32 pages. General Electric Co., Plainville, Conn. B

Circle 604 on Page 19

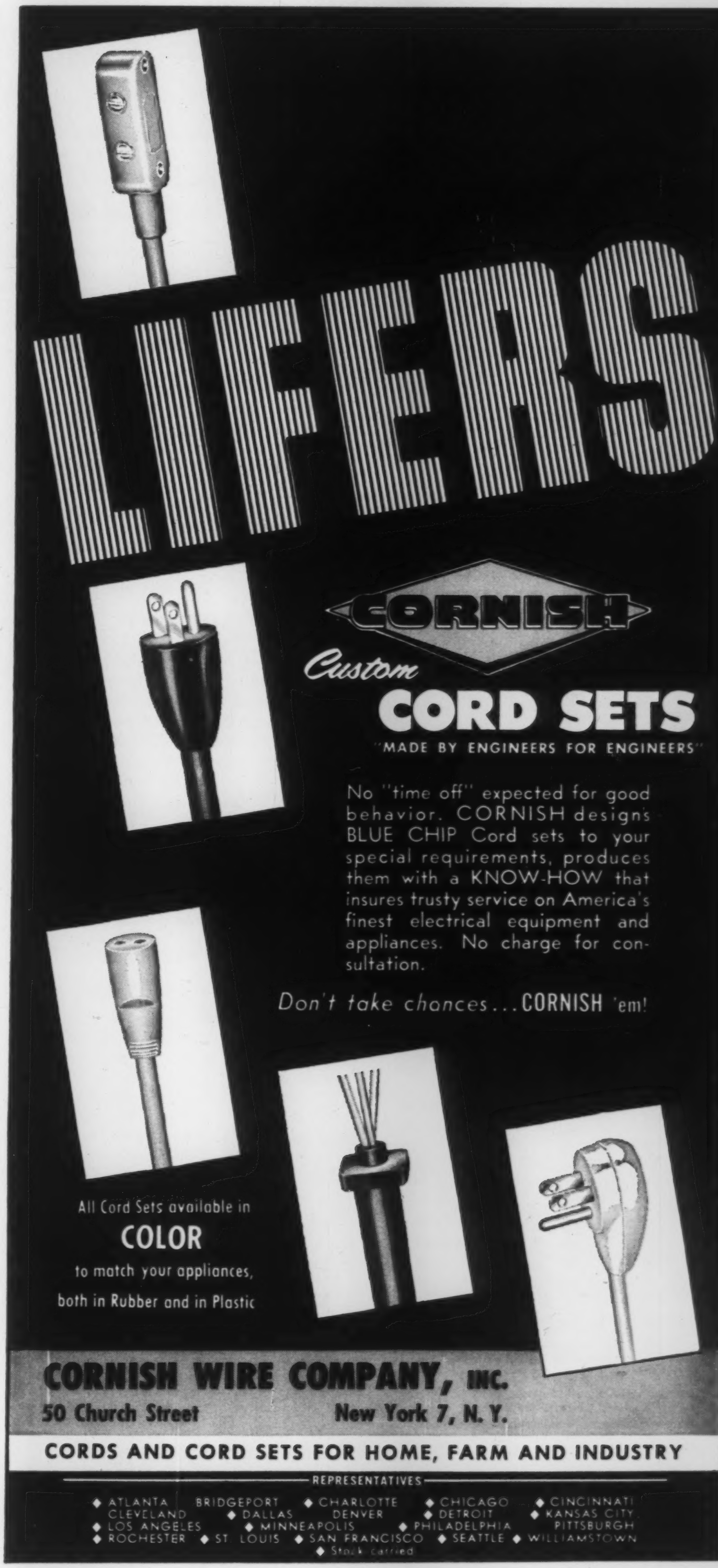
Pump Motors

Totally protected pump motors from $1/8$ to 1000 hp are discussed in Bulletin B-2507. In addition to describing features, bulletin explains the concept of attaching the motor frame directly to the pump frame. 4 pages. Reliance Electric & Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio. F

Circle 605 on Page 19

Safety-Relief Valves

Information for the selection and sizing of nozzle safety-relief valves applicable to process piping is featured in Catalog FE-118. Sizing factors and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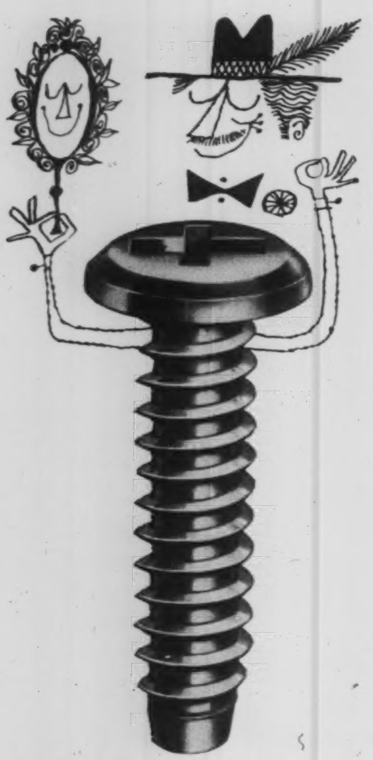
Circle 472 on Page 19



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Circle 473 on Page 19

formulas; nozzle capacity charts for air, water, gas, and steam; and dimensions and weight tables are provided. 44 pages. Farris Engineering Corp., 702 Commercial Ave., Palisades Park, N. J. D

Circle 606 on Page 19

Miniature Molded Parts

Various types of miniature nylon bobbins and molded nylon parts are illustrated in bulletin. Engineering data are offered to assist in designing new parts. 4 pages. Pee-Wee Molding Corp., Dept. 57A, 1720 Atlantic Ave., Brooklyn 13, N. Y. D

Circle 607 on Page 19

Metallic Sealing Rings

Performance and use of metallic sealing rings is covered in comprehensive Brochure 895-M68. It shows four major types of rings and their typical applications. Of interest to design engineers is a 4-page specification table on the most widely used sealing rings. 8 pages. Koppers Co., Metal Products Div., 200 Scott St., Baltimore, Md. C

Circle 608 on Page 19

Pilot Light Assemblies

Condensed technical information provided in Form L-161 covers Dialco pilot light assemblies and appropriate lamps. Required voltage, mounting provisions, insulation, lenses, and terminals are discussed. 16 pages. Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y. D

Circle 609 on Page 19

Hydraulic Controls

Bulletin 171 is descriptive of manual, stem operated, cam operated, air piloted, and solenoid control valves for hydraulic service at pressures to 3000 psi. Two sizes are available for 12 and 18 gpm flows. 12 pages. Dukes Hydraulics, 3999 N. 25th Ave., Schiller Park, Ill. J

Circle 610 on Page 19

Tubing Fittings

Design data given in illustrated Bulletin No. 3061-A on Hi-Seal tube fittings include recommended maximum working pressures, specifications of various types, and complete dimensions. Conforming to JIC and ASME codes, fittings are made in steel and stainless steel. 28 pages. Imperial Brass Mfg. Co., 6300 W. Howard St., Chicago 31, Ill. J

Circle 611 on Page 19

Forged Steel Flanges

Approximate weights of forged steel flanges are found on Data Sheet FDC-251. They are classified by pressures from 150 to 2500 lb. 2 pages. Babcock & Wilcox Co., Tubular Products Div., Milwaukee 46, Wis. K

Circle 612 on Page 19

4-Way Valves

Comprehensive engineering data on Denison four-way, $\frac{1}{4}$-in., solenoid-operated valves for 3000 and 5000-psi systems are content of illustrated Bulletin VD-8-B. Engineering drawings and di-

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Circle 474 on Page 19

rection of oil flow information are included for all models. 8 pages. American Brake Shoe Co., Dension Engineering Div., Columbus 16, Ohio. G

Circle 613 on Page 19

Plastics Molding

Company's facilities for designing and producing any type of injection molded plastic part regardless of size or complexity are pictured and described in bulletin entitled, "Development and Progress." 12 pages. Lincoln Molded Plastics, Inc., Circleville, Ohio. G

Circle 614 on Page 19

Hydraulic Tube Fittings

Engineering details plus ordering and installation instructions for straight thread hydraulic tube fittings are found in illustrated Catalog 058. Fittings fit all SAE portholes and are offered in several types from 1/4 to 2 in. OD. Specifications and drawings of each type are included. 20 pages. Flodar Corp., 16911 St. Clair Ave., Cleveland 10, Ohio. G

Circle 615 on Page 19

Threaded Fasteners

Nearly 10,000 sizes, diameters, and lengths of threaded fasteners, rods, and stud bolts are listed in combination catalog and price list. Made of several commonly used metals, they are listed with various technical data. Plastic-bound catalog is divided into nine sections. R.E.C. Corp., Cedar Street, New Rochelle, N. Y. D

Circle 616 on Page 19

Aluminum-Iron Alloys

Aluminum-iron alloys with from 13 to 17 per cent aluminum are used in the electric, electronic, and aircraft industries as soft magnetic materials and core materials. Subject of illustrated Technical Data Bulletin IND-18, the alloys are offered in various forms. Properties and test data are given. 4 pages. Metals & Controls Corp., General Plate Div., Attleboro, Mass. B

Circle 617 on Page 19

Filmed Data Standard

Simplified drafting, minimum letter heights, and line and background densities for active engineering drawings to be microfilmed, unitized, and reproduced in reduced sizes by electrostatic printing and offset are discussed in bulletin "Drafting Standards for Microfilmed Engineering Drawings." 8 pages. Filmsort Co., Pearl River, N. Y. D

Circle 618 on Page 19

Perforated Materials

General catalog of perforated materials No. 75 contains complete data on properties, available patterns, metals and alloys, and other information of use to design engineers. Typical uses of various materials in all types of equipment are illustrated. 156 pages. For free copy, write on company letterhead to: Harrington & King Perforating Co., 5670 Fillmore St., Chicago 44, Ill. I

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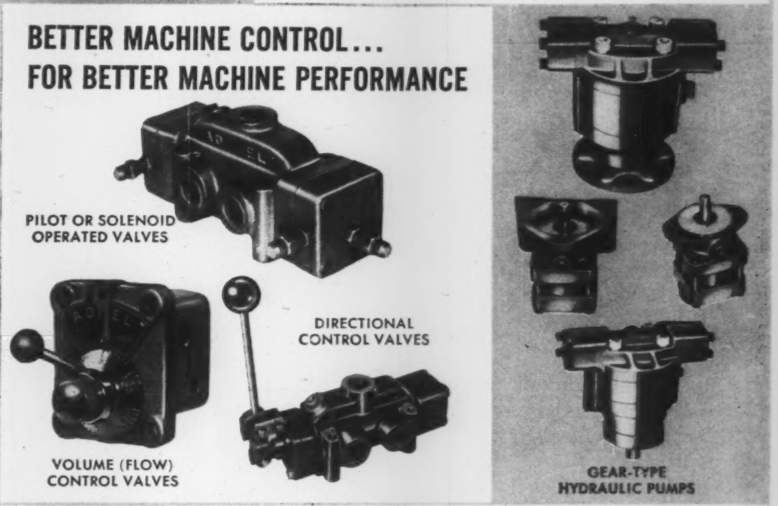
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The diagrams show but two of innumerable circuits and systems where these versatile pumps and control valves can be used to advantage.

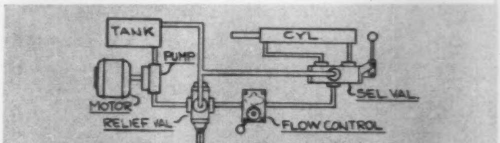

Diagram illustrates typical circuit showing control of cylinder.

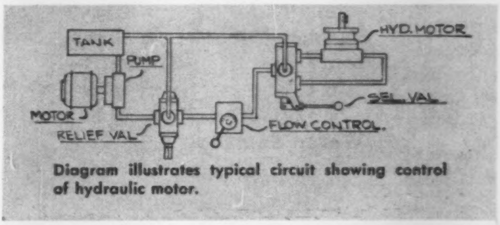

Diagram illustrates typical circuit showing control of hydraulic motor.

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Circle 475 on Page 19

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Dry Bearing Material

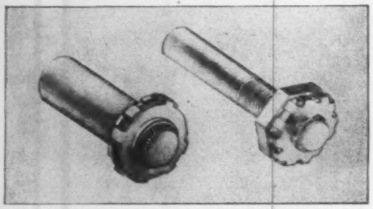
with operating temperature range from −328 to 536 F

New dry bearing material, known as DU, is available for use in the automotive, appliance, industrial machinery, and aircraft industries. Material is composed of a steel backing on which is sintered a thin lining of spherical bronze, impregnated with a mixture of Teflon TFE and 20 per cent lead, a thin layer of which also covers bearing surface. The TFE-lead-impregnated bronze structure comprises two completely interlocked spongelike networks. Material has low friction with no slip-stick characteristics, superior wear resistance, high thermal conductivity, and low thermal expansion. Compressive strength is up to 23 tons per square in., and operating temperature range is from −328 to 536 F. It is available in strip form in a range of thicknesses, from which bushings can be wrapped, thrust washers cut, or hemispherical bearings pressed. **U. S. Gasket Co., Div., Garlock Packing Co.,** Camden 1, N. J. E

Circle 619 on Page 19

Lock Washers

for use on vibrating assemblies



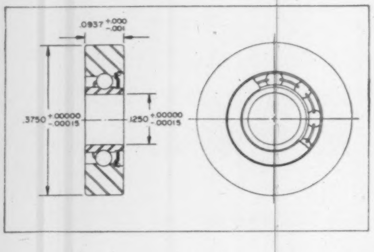
New serrated (right) and bearing lock washers (left) provide a positive torsional lock between nut and bolt. Washer fixes itself positively against rotation to the bolt by means of serrations on protruding bolt thread. Washer tangs retain hexagon of standard nut or slots of a ring nut firmly against rotation. Tangs are provided with a positive snap lock to prevent lock washer from moving axially. Since lock is applied on top of nut, it does not affect any highly stressed area, therefore does not affect fatigue qualities of any nut-bolt connection. Nut can be torqued to give any preload and does not require backing off to make serrated nut lock washer fit. Serrations on top end of bolt thread do not affect thread and are ready for reuse with a new washer at any time. Washers are primarily for use in vibration assemblies. **Shur-Lok Corp.,** 879 South East St., Anaheim, Calif. L

Circle 620 on Page 19

Wafer Bearings

have narrower than standard widths

New Microwafers are narrow-width bearings for use in synchros, servos, small motors, potentiometers, and gear trains. Thin design allows more iron and copper to be added to rotors and stators without increasing over-all length of unit. Bearings are available in a wide variety of shaft and housing diameters. Available bore diameters range from 0.0937 to 0.1875 in. Housing diameters are from 0.2500 to 0.4375 in. All units are 440C stainless steel, and have tolerances of ABEC 7 or better. **New Hampshire Ball Bearings Inc.,** Grove St., Peterborough 11, N. H. B

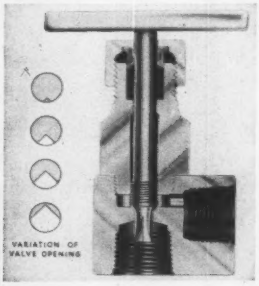


Circle 621 on Page 19

Bar-Stock Valve

utilizes tapered orifice to eliminate clogging

Veegroo bar-stock valve utilizes a tapered orifice to eliminate clogging. Moving a plug with tapered slot into and out of a circular opening controls flow of fluid or gas. Valve passes foreign particles up to twenty-five times larger than comparable needle valves. Pressure ratings are 3000 and 10,000 psi, and materials available are carbon steel, 303, 316, or 416 stainless steel, Alloy 20, Monel, and aluminum. **General-American Valve Co.,** P. O. Box 444, Corona del Mar, Calif. L

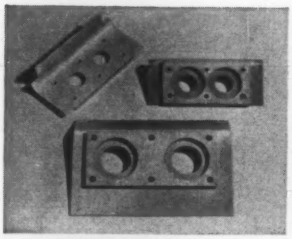


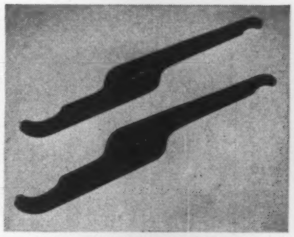
Circle 622 on Page 19

O-Rings

in sizes 1 to 27

MinJecto O-Rings are standard Buna-N compound 366Y, available in sizes 1 to 27. They are flashfree,


BAFFLE PLATES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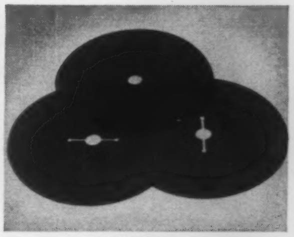
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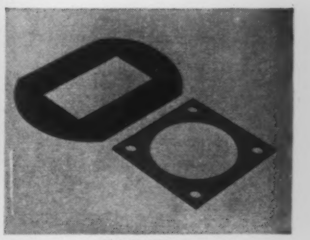
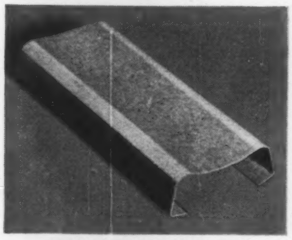
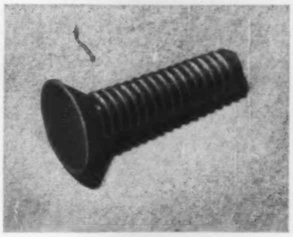
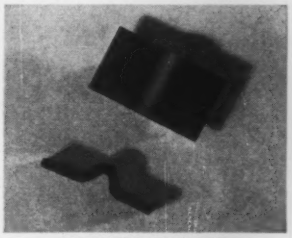

GASKETS


FORMED INSULATOR


SCREW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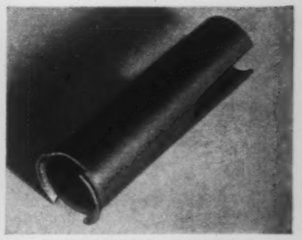
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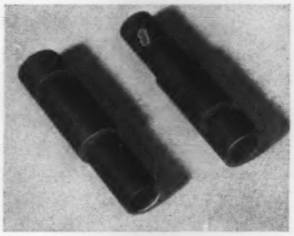
CABLE SUTURE
SPOOL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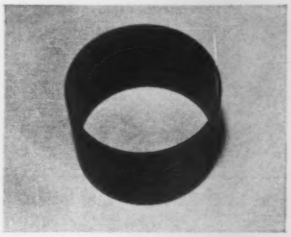
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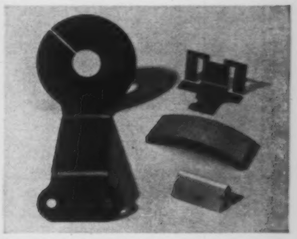
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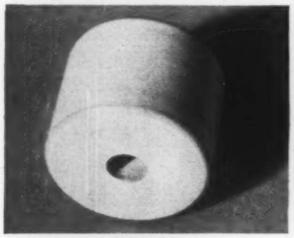
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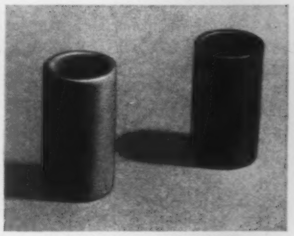
NUMBER TAG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Circle 476 on Page 19

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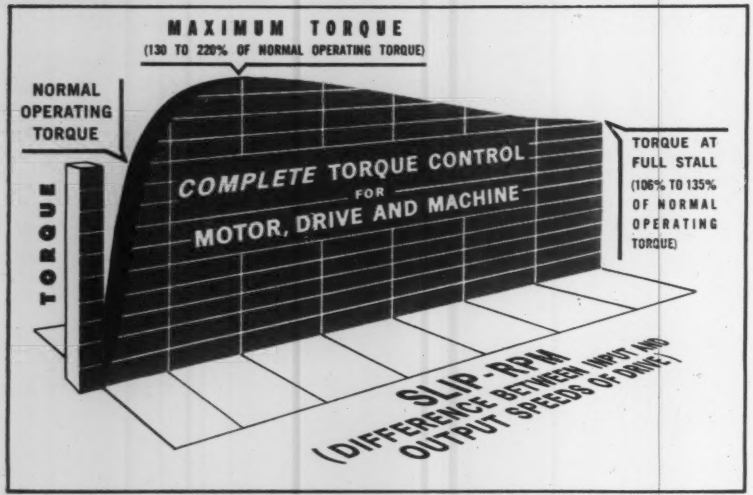

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New 8 page Whitney-Tormag Magnetic Drive technical bulletin — be sure to get your copy!

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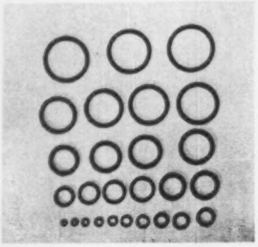
Circle 477 on Page 19



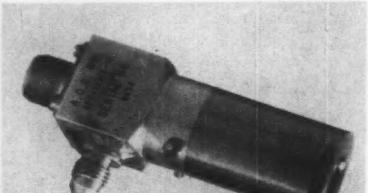
have high density, and exceptionally close tolerances. Rings have excellent resistance to chemicals and high friction resistance over long service life. **Minnesota Rubber Co.,** 3630 Wooddale Ave., Minneapolis 16, Minn. J

Circle 623 on Page 19

High-Pressure Switch

for corrosive atmospheres

GPP12123-G1 pressure switch, suitable for burst pressures to 20,000 psi, can be used in corrosive atmospheres with no leakage at 6600 psi while being subjected to temperatures of −65 F and vibration to MIL-E-5272A. Switch withstands ambient temperatures to 275 F. Made of stainless steel, switch is rated 28 v dc, 5 amp resistive and 2½ amp inductive, single pole, double throw. Use of a sealed piston pressure-sensing element insures no leakage at high pressures. **Aircraft Controls Co., Div., Gorn Electric Co. Inc.,** 845 Main St., Stamford, Conn. B



Circle 624 on Page 19

Speed Reducer

in new in-line shaft model

New series of in-line shaft models has been added to a line of parallel-shaft step-function speed reducers. In-line, ¼-in., stainless-steel shafts allow more convenient mounting in drives for timers, charts, oscillators, and in laboratory breadboards. Tur-

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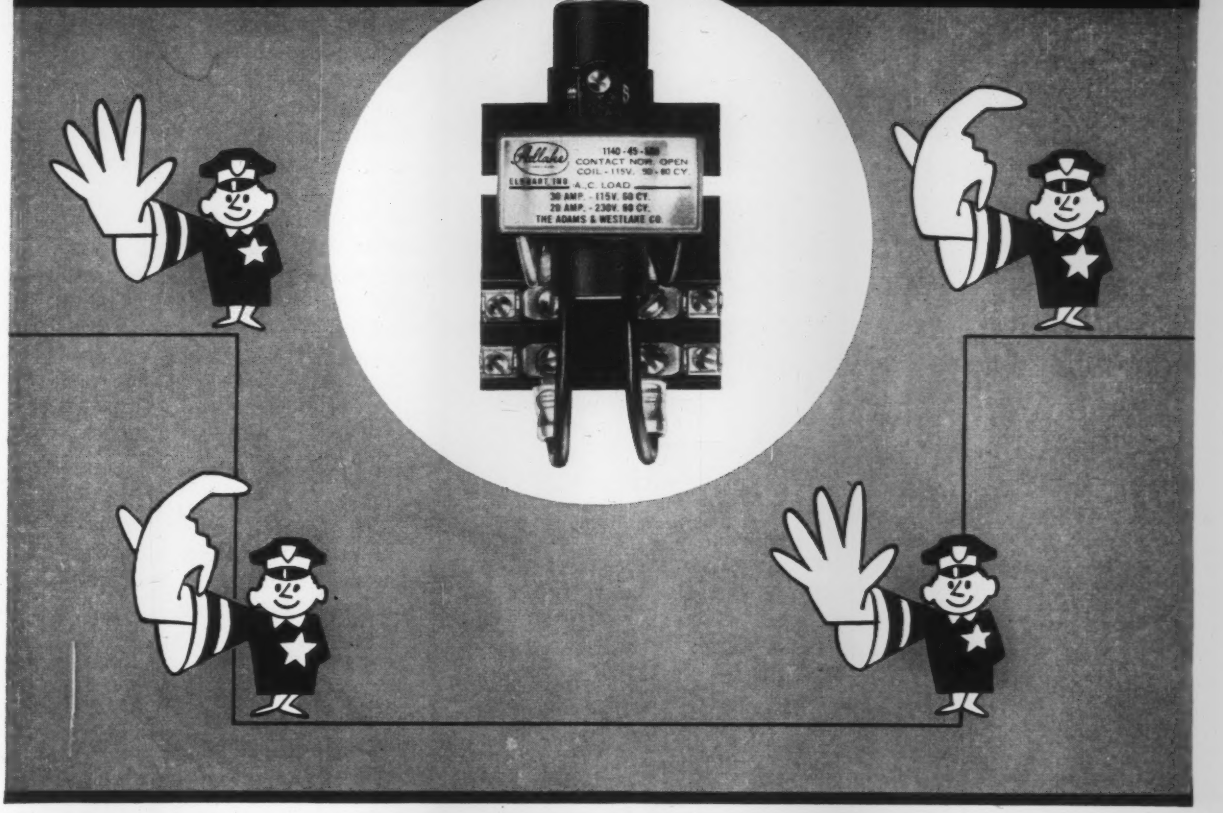
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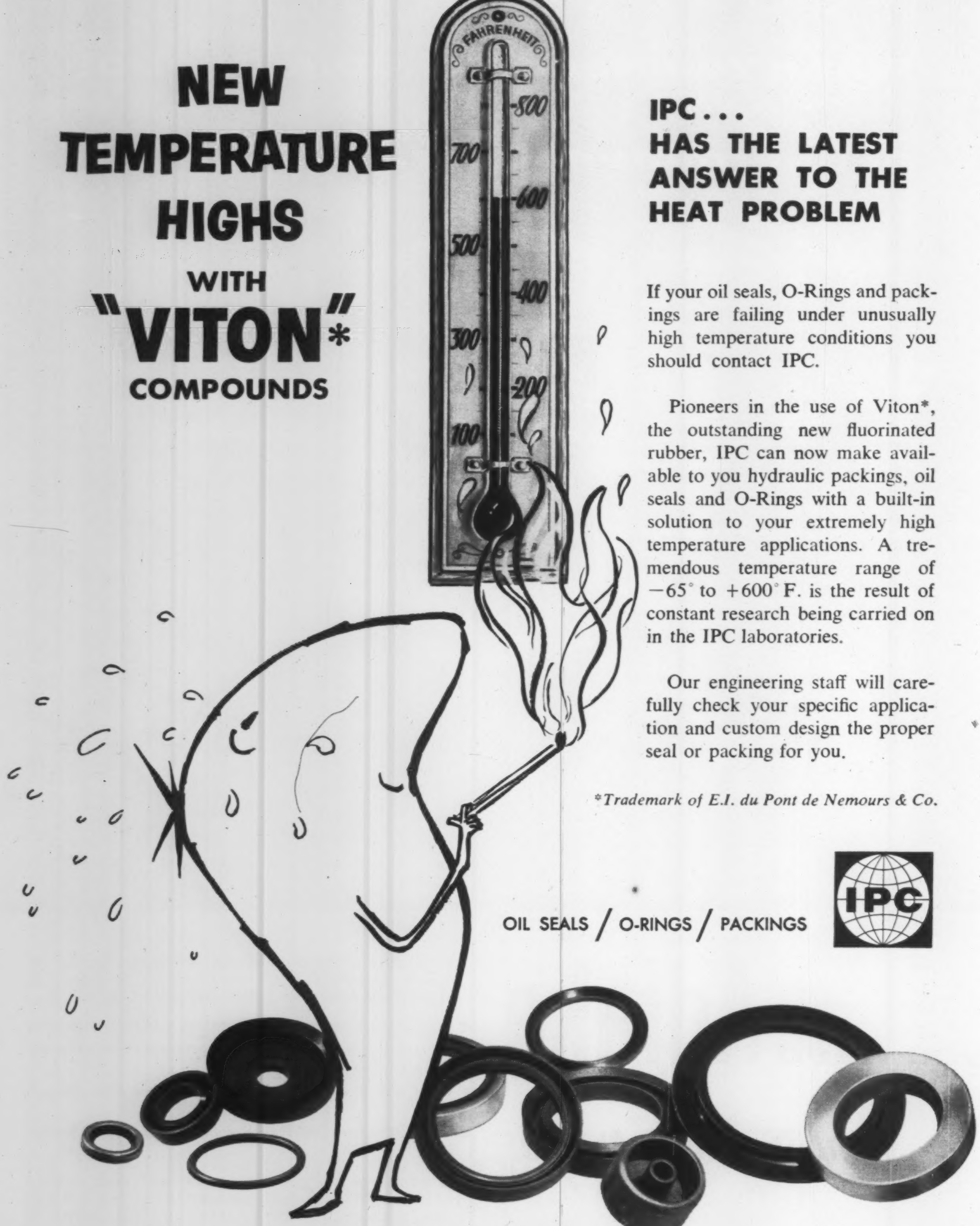

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OIL SEALS / O-RINGS / PACKINGS

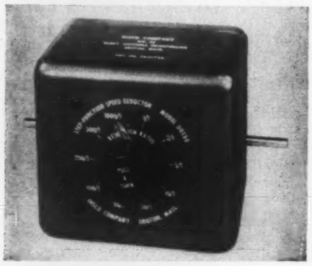
IPC

INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

P4

ret-mounted gear train can be rotated to select any of ten output ratios by pulling and turning selector knob. Pulling knob decouples input drive shaft, allowing ratios to be changed without stopping input shaft rotation. Geared design ensures positive, no-slip drive, with exactly repeatable ratios available to 1000:1. Unit is recommended for continuous duty to 1500 rpm, intermittent duty to 3000 rpm, with output torque capacity to 50 oz-in. Five models are available with various combinations of ratios. **Insco Co., Div., Barry Controls Inc.,** Hollis Street, Groton, Mass. B



Circle 625 on Page 19

Sheet Alloy

has excellent stain-resisting properties

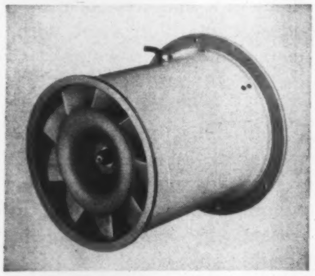
New sheet alloy possesses bright finish and excellent stain-resisting properties. Applications are in the manufacture of cooking utensils, jewelry, optical frames, appliance trim, and other products requiring a lustrous, enduring finish. **Aluminum Co. of America,** 743 Alcoa Bldg., Pittsburgh 19, Pa. F

Circle 626 on Page 19

Miniature Blowers

have integral electric motors

Small vane-axial air-moving units are for electronic equipment cooling



Circle 480 on Page 19→

LONG LIFE, *THOMSON* "Snap-In"

NYLINERS®

of smooth, tough DuPont NYLON

Low Cost FLANGED Nyliner

Low Cost SLEEVE Nyliner

Low Cost DOUBLE-FLANGE Nyliner

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- RESIST POUNDOUT
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- NON-CONTAMINATING
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- REDUCED WEAR

Engineered to Solve Problems . . . Improve Products . . . Reduce Costs!

NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.

**In production quantities at new, REDUCED PRICES.*

THOMSON INDUSTRIES, Inc.

DEPT. 4, MANHASSET, NEW YORK

Also—Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting

Billions of GROOV-PINS have done perfect fastening jobs

For thirty years many of the world's leading manufacturers have used Groov-Pins in an infinite variety of applications. Groov-Pin was the first of the press fit pin fasteners and many design engineers believe it is still the best.

Groov-Pins are made from cold rolled steel (or other metals according to customers' requirements). Longitudinal grooves are rolled or pressed into these pins, deforming the stock within controlled limits. When a Groov-Pin is forced into a hole, the constraining action of the hole wall causes displaced material to flow back, effecting a locking fit within its elastic range.

Only a straight drilled hole is needed—no special hole preparation such as reaming, tapping, milling, etc.

Also manufacturers of Tap-Lok Inserts.

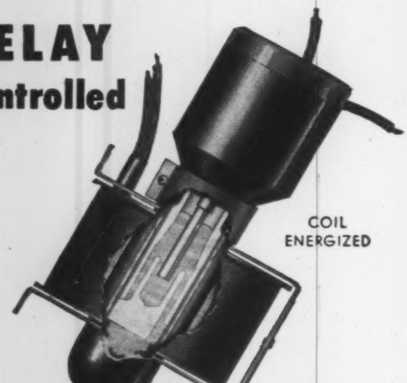
Send for further information.
1130 Hendricks Causeway, Ridgefield, N. J.
TWX: Cliffside 26
Representatives in principal cities throughout the U. S. A.
IN CANADA: Metal and Wood Fastening Devices Co.
60 Lakeshore Road, Valois, Montreal 33

GROOV-PIN CORPORATION

Circle 481 on Page 19

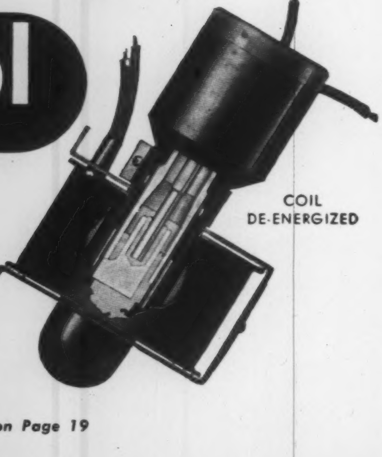
The TIMER RELAY that handles all controlled timing problems . . .

This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.



Durakool
STEEL MERCURY TIMERS

- ★ No false contacts
- ★ Non sticking
- ★ Practically "fail safe"
- ★ Low cost timer



See telephone directory for local distributor, or write.

DURAKOOL, INC.
ELKHART, INDIANA, U. S. A.
700 WESTON RD., TORONTO 9, CANADA

Circle 482 on Page 19

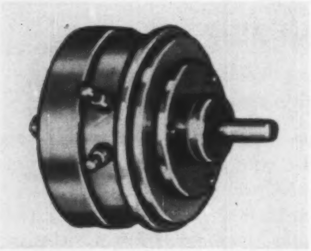
and other blower applications where space is limited. Fans can be furnished in a variety of housing shapes, sizes, flange designs, finishes, and mounting arrangements. Line includes both single and two-stage units, and all are direct-drive type with integral electric motor. Single-stage blower, shown, is designed for cooling large electronic equipment and inflating military radomes. Rated at 7/8 hp at 5600 rpm, it delivers 700 cfm air at 4.0 in. water static pressure. **American-Standard, American Blower Div.,** Detroit 32, Mich. H

Circle 627 on Page 19

Pancake Clutch

for close-coupled operations

Model PC-8 precision clutch, half as long as its mounting diameter, is designed for close-coupled operations. Unit features encapsulated coils and fixed terminals, and is vibrationproof per MIL-E-5272A. Servo mounting diameter is 1.000 in., and length from servo flange to cap is 0.500 in. ABEC-5 instrument ball bearings are used throughout. Unit has torque of 16 oz-in. and weighs 1.85 oz. **Autotronics Inc.,** Rte. 1, Box 812, Dept. 14, Florissant, Mo. I



Circle 628 on Page 19

Flexible Drive Couplings

of magnesium alloy

Magnaloy flexible drive couplings are made of a magnesium alloy that provides strength of steel with 80 per cent reduction in weight. Couplings are slipped over shafts and made tight through the use of separate split hubs which fit into coupling halves. Socket-head screws draw the two together, compressing split hub around shaft. All hubs, regardless of bore size, are interchangeable in couplings of each

Tubexperience in action

* A GOOD REASON FOR PREFERRING SUPERIOR

Special mill services through your Superior Tube distributor

* You may be faced with the need for tubing services that only highly competent specialists at the mill can provide. You may need small tubing in hard-to-get analyses. Or of special shapes, held to very close tolerances. Or with a closely controlled range of properties. Perhaps it must also undergo rigid inspections and tests not normally available from tubing suppliers.

Requirements like these call for a tubing specialist.

CONTACT A SUPERIOR TUBE DISTRIBUTOR

His broad experience can help you solve many problems. But most important of all—he can acquaint you in detail with many special services offered by the mill. These include statistical quality control, nondestructive tubing inspection and testing, pilot and test lot sampling and melting, field specialist and specification services—there are many more.

EQUIPPED TO SERVE YOU

You will find that your Superior distributor has a modern steel service center equipped to meet all your requirements in tubing. He offers you:

- Small tubing in many analyses
- Wide range of sizes
- Tubing of highest quality for any applications
- Diversified stock
- Prompt price quotations and delivery
- Use of his warehouse for your firm's tubing inventory

For more information about Superior tubing, write for a free copy of Bulletin 40, "A Guide to the Selection and Application of Superior Tubing." Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

Circle 483 on Page 19

MEMO TO L.B.
FROM A.R.

We need one source for all types of chain. How about UNION CHAIN?

You couldn't do better. And here's why. We make *all* types of steel drive and conveying chain plus sprockets and attachments. We can supply you with the chain you need, whatever the application. And of course it follows from this that our engineering experience is broad and our recommendations are completely unprejudiced. The Union Chain organization is at your service.

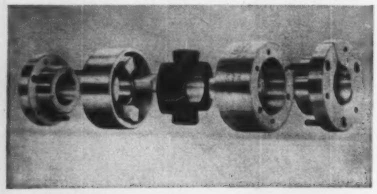
TRANSMIT POWER
UNION® CHAINS
CONVEY MATERIALS

Consult Your Nearest Union Chain Distributor

The Union Chain And Manufacturing Company

P. O. BOX 651, SANDUSKY, OHIO

Circle 484 on Page 19



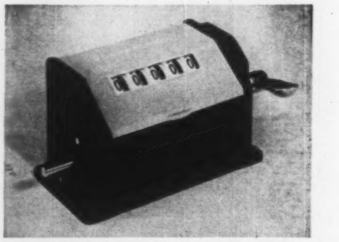
model size. Drive is transmitted through a lugged Neoprene drive insert, providing an insulated, nonlubricated connection, absorbing misalignment and shock. Made in eight sizes, couplings accept from ¾ to 6-in. shafts. **Detroit Power Coupling Co.**, 992 W. Seven Mile Rd., Detroit 3, Mich. H

Circle 629 on Page 19

Quick-Reset Counter

has capacity of 100,000

Series 1522 counter is available with or without predetermining wheels. With predetermining, wheels can be preset to any number within capacity of 100,000; counter automatically knocks off at that number. Instant resetting to zero is accomplished by depressing reset lever through 60-deg arc. Counter will also subtract in opposite direction if desired. Speeds up to 6000 rpm of the drive shaft and 8000 counts per min are recommended maximum. Without predetermining, counter is suitable for all counting jobs where high speed, accuracy, and easy, instant resetting are required. **Veeder-Root Inc.**, Hartford 2, Conn. B

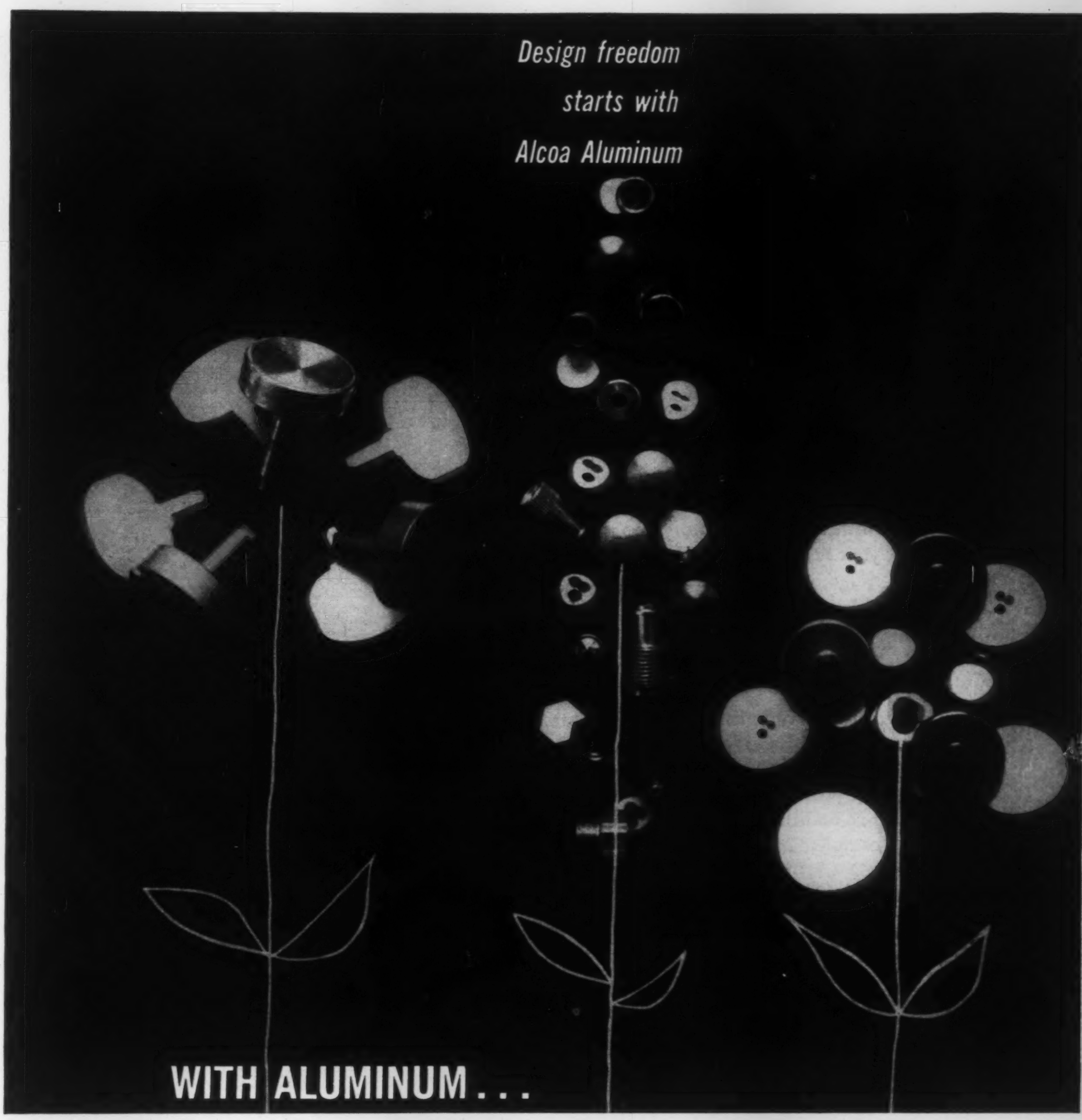


Circle 630 on Page 19

Quick-Release Pins

are available with six handle configurations

New Ball-Lok pins are available in three materials and six handle configurations. Pin material is non-heat-treated B-1113 steel screw stock, or 4130 chrome moly steel,



YOU CAN GET SCREW MACHINE PARTS IN ANY COLOR

Switch to *color-anodized* parts of ALCOA® Aluminum and add a new dimension to your next product design. Choose any shade for harmony or identification. (Sales appeal?—ask the camera manufacturers.) It's lustrous, lasting color that's part of the metal—color that doesn't distort dimensions.

And color anodizing has another side—the weather side. The tough oxide film formed in the process virtually ends corrosion and abrasion. It's not a painted or plated surface, so there's no chipping or peeling.

Of course, color's only part of the story. You save important product pounds with aluminum without sacrificing strength or performance. Designers of business machines, projectors, outboard motors have proved it.

Aluminum gives exceptional machinability, limited almost entirely by machine capacity; high electrical and thermal conductivity; and choice of any finish. It always weighs less and frequently costs less than steel or brass.

ALCOA's new booklets about screw machine stock contain direct quotes from designers, production engineers and purchasing agents of leading industries on why they switched to aluminum. We'd like you to have a copy.

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

Look for this label . . .
it's your guide to the
best in aluminum value

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Exciting Adventure
ALTERNATE MONDAY EVENINGS

Aluminum Company of America
873-G Alcoa Bldg., Pittsburgh 19, Pa.

Please send your new booklets about aluminum screw machine stock with direct quotes from industry leaders on why they switched to Alcoa Aluminum.

Name____________________
Position____________________
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Address____________________
City__________Zone___State______

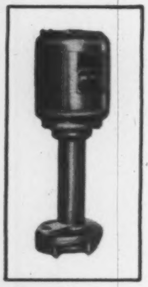
Circle 485 on Page 19

machinery builders
specify
MOTORPUMPS
for low-cost
efficiency . . . .

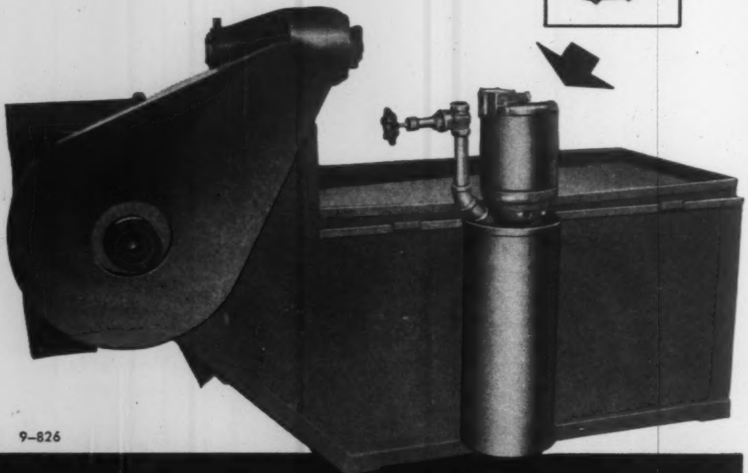
Their long record of dependability and efficiency . . . their many design features . . . their adaptability to many types of machines, has proved that Ingersoll-Rand Motorpumps offer advantages not found in any other pump.

Whatever your liquid handling requirements, there is a Motorpump that can meet your needs exactly. Select from the widest range of types, sizes and mountings available anywhere. You can save important time and money because Motorpumps are designed for easy adaptability to most equipment.

Why not consult with a thoroughly trained Ingersoll-Rand pump specialist who can help you with your liquid moving problem. Call your nearest I-R branch office or write for complete information.



A magnetic separator in which an Ingersoll-Rand immersion type Motorpump has been incorporated.

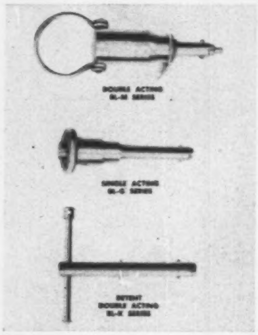


9–826

Ingersoll-Rand 11 Broadway, New York 4, N. Y.

Circle 486 on Page 19

heat-treated to 160,000 to 180,000 psi, meeting military specifications MIL-T-6736A and MIL-S-6758. Standard pin finish is cadmium plate. Pins for high-strength applications are 17-4 stainless steel, heat-treated to 180,000 to 210,000 psi, meeting AMS-5643C. BL-M Series are double-acting, positive-locking pins that vibration or an accidental pull on safety chain cannot release. BL-G pins are single-acting, positive-locking units that release only when operator manually pushes release button and pulls pin in one motion. BL-K pins are double-acting units that are detent positioned. **D. W. Price Corp.**, 11161 W. Pico Blvd., Los Angeles 64, Calif. L



Circle 631 on Page 19

Magnesium Alloy

has excellent damping capacity

K1X1 magnesium alloy is useful where exceptional vibration resistance is required, as in missile and aircraft electronics equipment. Alloy, which contains 0.4 to 1.0 per cent zirconium, provides a combination of excellent damping capacity, light weight, good mechanical properties, corrosion resistance, and castability. It has very low electrical resistance, is nonferromagnetic, and can be welded readily. **Dow Chemical Co.**, Midland, Mich. H

Circle 632 on Page 19

Adjustable-Speed Drives

for constant-torque or constant-power applications

New adjustable-speed drives, designated Rectiflow, afford continuously variable speed control over speed ranges of $1\frac{1}{2}$:1, 2:1, or 3:1, with maximum speed of 1690 rpm. All

NATIONAL OIL SEAL LOGBOOK

Ask yourself these questions when specifying oil seals

SHAFT RPM, FPM, RUNOUT, ENDPLAY	Is seal rated at or above my anticipated operating extremes? ☐ YES ☐ NO
TEMPERATURE, LUBRICANT TYPES	Will heat or special-purpose lubricants attack my sealing lip compounds? ☐ YES ☐ NO
PRESENCE OF DIRT OR OTHER FOREIGN MATERIAL	Point often overlooked. If present, should I specify dual-lip sealing member? ☐ YES ☐ NO
COST RELATED TO SEAL DESIGN	Will a simpler, less expensive seal do as good a job as a more sophisticated unit? ☐ YES ☐ NO
NEW SEAL DESIGNS AND MATERIALS ON MARKET	Are there new high temperature, high speed compounds I should examine before specifying? ☐ YES ☐ NO
SPECIAL DESIGNS FOR SPECIAL PROBLEMS	Not all sealing jobs can be met with stock seals. Do I need a special factory design? ☐ YES ☐ NO
DELIVERY, REPUTATION FOR QUALITY	Is my resource noted for on-time delivery, uniform quality, and good follow-up service? ☐ YES ☐ NO

Don't specify "blind." Your National Oil Seal Engineer has up-to-date data on seals—old, new and under development. He understands current sealing parameters; what special designs can probably be developed. His frank, free counsel can't help but lead to better sealing, faster assembly, simpler servicing, faster delivery or lower cost.

Call him today. Number's in the Yellow Pages, under Oil Seals.

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Redwood City and Downey, California
Van Wert, Ohio

NATIONAL OIL SEALS

4869

IT PAYS TO HAVE HUBBELL GOOD CONNECTIONS

FROM ASSEMBLY START TO FINISH, HUBBELL PRECISION SCREWS ARE USED IN THE TYPE J2S WATTHOUR METER MANUFACTURED BY SANGAMO ELECTRIC COMPANY, SPRINGFIELD, ILLINOIS.

SECURED WITH HUBBELL PRECISION-QUALITY MACHINE SCREWS

Each of the twenty-five Hubbell machine screws shown at left are vital components in this Sangamo Type J2S Watthour Meter. Each shares the responsibility for keeping the assembly operation flowing smoothly, and each makes its own contribution to the overall dependability and accuracy of the unit. All along the line the advantages of Hubbell precision screws pay off. Clean threads, well formed heads, deep, clean slots, uniform size . . . all of these quality features help to secure Sangamo quality and reduce assembly costs.

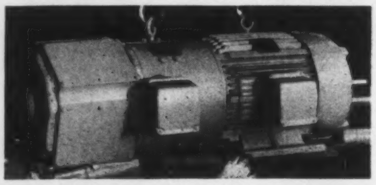
Here again, experience proves that the finest materials and components are always *lowest in cost to service.* Are you putting this time-tested principle into practice? Start today by specifying Hubbell quality fasteners. Prices and delivery on request. Simply send blueprint or sample of the item.

. . . and don't overlook these premium miniatures
. . . the finest obtainable . . . available in steel, stainless steel or brass; and in head styles and sizes to meet your requirements.

HARVEY HUBBELL, INC.
HIGHEST QUALITY
WIRING DEVICES • MACHINE SCREWS

OVER 60 YEARS' EXPERIENCE in the manufacture of highest quality, rolled thread machine screws and special cold headed parts.

MACHINE SCREW DEPARTMENT BRIDGEPORT 2, CONNECTICUT



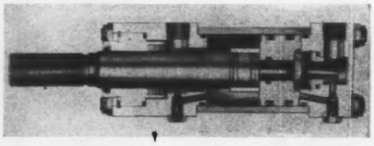
power requirements are supplied from normal ac distribution systems. Presently available in ratings of 7½ to 125 hp or higher, they serve either constant-torque or constant-horsepower applications. Drives consist of a wound-rotor motor and a dc motor built on a common output shaft. Semiconductor rectifiers rectify slip power from wound rotor to supply direct current to the dc motor armature. Moving parts are limited to those normally found in wound-rotor motors. Second set of rectifiers convert ac line voltage to dc to energize shunt field of dc motor. Speed control is obtained by varying setting of a rheostat in shunt field circuit. **Westinghouse Electric Corp.,** P. O. Box 2099, Pittsburgh 30, Pa. F

Circle 633 on Page 19

Cylinders

for air and hydraulic operation

New Automation air and hydraulic cylinders are designed to automotive industry standards for high-speed, automatic production. Cylinders operate at pressures of 2000 psi air and 1000 psi for hydraulic operation. Units meet JIC standards. **Ortman-Miller Machine Co. Inc.,** 7 143rd St., Hammond, Ind. J



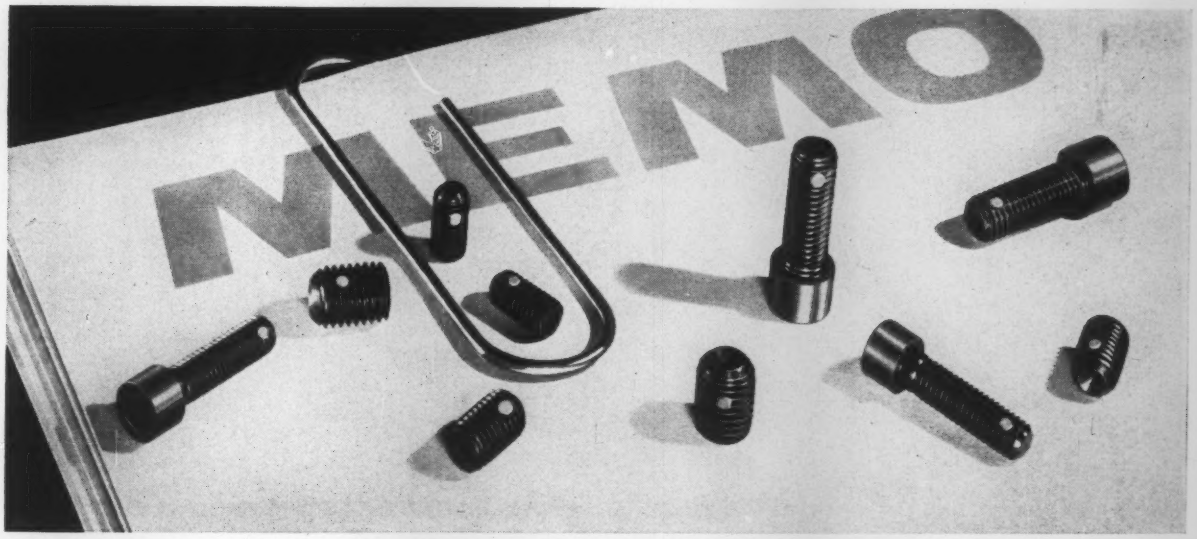
Circle 634 on Page 19

Potentiometer

linear-motion unit is subminiature size

Model 141 Linipot is for applications in hydraulic actuators, pneumatic valves, and linkage systems where space is limited. Body length is 1¼ in. and cross-section is ¼ x 5/16 in. Instrument gives a precise electrical indication of travel

Circle 488 on Page 19



Self-locking microsize UNBRAKO socket cap and set screws are available in sizes #0 through #3, in heat treated alloy steel and 18-8 stainless steel, at your authorized industrial distributor. He also carries a complete stock of other self-locking UNBRAKO socket screw products.

Make Your Small Assemblies More Reliable with Self-Locking Microsize UNBRAKO Socket Screws

hiRf
High Reliability factor

At SPS we apply a dynamic standard of quality—continually refined—so that our fasteners will always have the high reliability factor required by today's faster speeds, higher temperatures, and greater dynamic stresses. By using SPS fasteners in your assemblies, you increase overall reliability—the certainty of predictable performance under actual service conditions.

For more information on the full meaning of reliability, write for a copy of the new SPS booklet "High Reliability."

Self-locking microsize UNBRAKO socket screws help solve the problem of keeping fasteners tight in small assemblies. These miniature UNBRAKO socket cap and set screws with the Nylok* self-locking feature will not work loose under impact, shock or vibration.

Microsize UNBRAKO socket screws with Nylok simplify fastening of small assemblies where vibration would otherwise require lock-washers, wiring, adhesives or other special means of securing tiny screws. Microsize UNBRAKOs with Nylok require no separate locking elements. They improve design, speed up assembly operations, cut production costs, simplify inventory. They increase reliability by eliminating auxiliary locking devices that sometimes fail in service by loosening.

An UNBRAKO with Nylok is a single, self-locking unit. The permanently installed, resilient nylon pellet—serviceable from —70 to +250°F—forces mating threads tightly together, locks the screw securely, seated or not, wherever wrenching stops. And it can be removed and reused without affecting the reliability of its locking action.

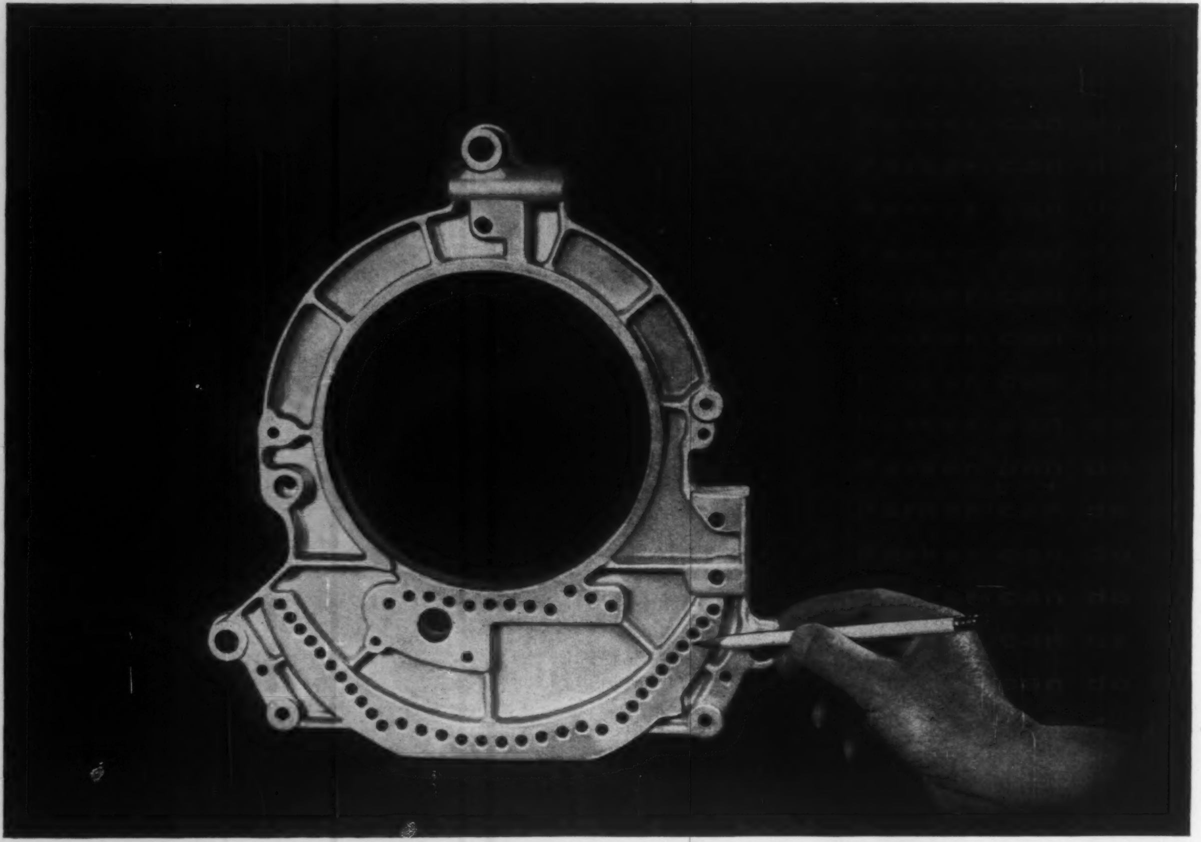
Your local SPS distributor stocks microsize UNBRAKO socket cap and set screws in standard sizes #0 through #3. See him for more information or write for Bulletin 2374. STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

*T.M. Reg. U.S. Pat. Off., The Nylok Corporation

We also manufacture precision titanium fasteners / write for free booklet

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.



The ~~W~~HOLE Story Of Die Casting Savings

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Hodgson-Geisler Co. • 18917 James Couzens

GIRARD, Penna.
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LONG BEACH 11, California
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MINNEAPOLIS 16, Minn.
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ST. LOUIS 8, Mo.
Frank May • 4378 Lindell Boulevard

SYRACUSE, N. Y.
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These close tolerance holes could have cost more than the part itself. Actually, *they cost practically nothing!* Parker-engineered die casting makes the difference. By means of precision coring, the holes are cast to exact diameter and location . . . a bonus in the low unit cost of producing the complete part. Just think of the savings compared with other production methods requiring finish machining.

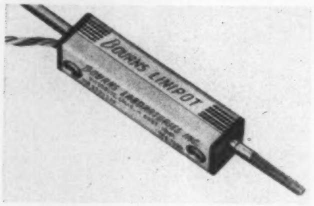
The creative engineering approach that made these savings possible has been the hallmark of Parker service since 1906. It is the plus factor that is never figured into a Parker estimate. If you are a Parker customer, you know this is so. If you are not, you can profitably prove it to yourself by consulting the nearest Parker sales engineer on your next component part requirement.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER

high pressure
die castings in
ALUMINUM • ZINC
POWDERED METAL PARTS

position and operates with a high-level ac or dc output, requiring no amplification. It is designed primarily for use in recording, control, and telemetering circuits. Standard travels for the wirewound unit are 3/16, 1/4, 5/16, 3/8, and 7/16 in., and resolution ranges from 0.0010 to 0.0030 in. Independent linearity is ±1.0 per cent, and standard resistance values are 500, 1000, 2000, 5000, and 10,000 ohms. Unit operates at temperatures from −67 to 221 F. Potentiometer is provided with printed-circuit pins, solder lugs, or flexible lead wires. **Bourns Laboratories Inc.**, P. O. Box 2112, Riverside, Calif. L

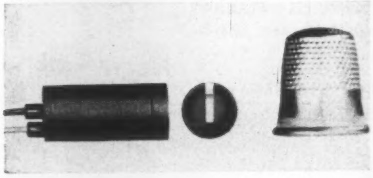


Circle 635 on Page 19

Moving-Coil Indicator

miniature unit
fits within other meters

Model HCM 7/16 miniature moving-coil indicator, having a diameter of 7/16 in., can be incorporated within other meters to indicate such information as alarm, position, and malfunction. A compact, hermetically sealed unit, it withstands extreme vibration. Indicator is available with either flag or pointer display, and in a variety of electrical sensitivities and functions. **Marion Electrical Instrument Co.**, Grenier Field, Manchester, N. H. B



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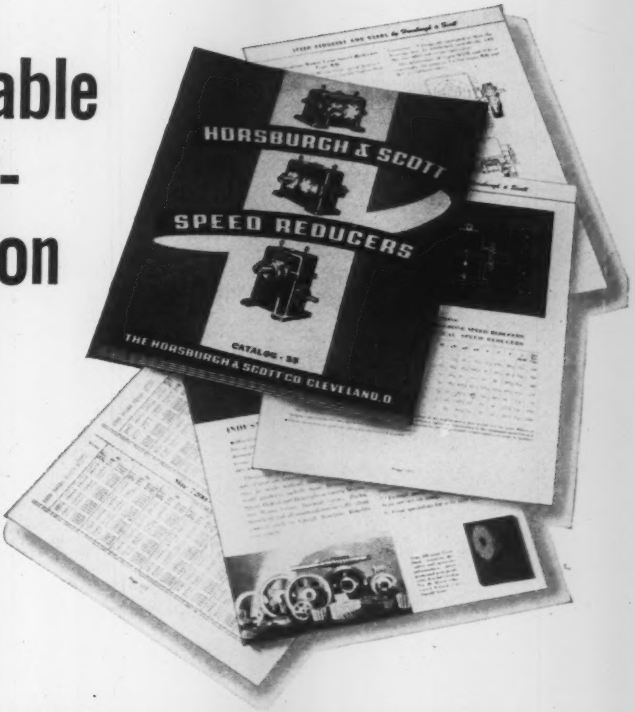
Diesel Engines

are rated 25 and 50 hp

Model 17B and 19B diesel engines are rated at 25 and 50 hp, respectively, at 2000 rpm. Features include replaceable wet-type liners, main



for valuable information

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on efficient speed reduction... Horsburgh & Scott Catalog 55

More than a catalog, this comprehensive book supplies all the information you need for the proper selection of speed reducers.

- Complete size range available, including new sizes.
- New ratios and ratings for Worm Helical Speed Reducers shown.
- Increased Overhung Load capacities are listed and explained.
- Detail dimensions of standard worms and gears are given to help you "build-in" Horsburgh & Scott Speed Reducers.
- New Rating Tables—more complete than ever before—easier to use.
- Engineering Data Section—more tables and data you want.

All this information and much more is in Catalog 55. It's yours for the asking. Just write us on your letterhead.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio

Circle 491 on Page 19

Solve Your
HOT PROBLEMS
with
VULCAN
VERSATILITY

IN FINNED
STRIP HEATERS

Vulcan Finned Strip Elements provide ideal heat for blower type electric unit heaters, duct heating, unit convection heating, as oven or space heaters in dryers, pump rooms, etc.

You have a wide choice of standard sizes — from 10½" to 42½"; wattage from 500 to 3250 or higher; voltage — 120, 240 or higher; steel, for sheath temperatures to 750°F; Chrom-alloy for temperatures to 1250°F; rugged non-oxidizing terminal posts.

When your hot problem calls for unusual specifications, you get a speedy solution through *Vulcan Versatility* in engineering and production. Standard or special, Vulcan is ready to supply your complete needs in low-cost efficient heating units — finned, cartridge, strip, tubular, immersion, band and ring heaters. Send coupon for catalog and prices.

VULCAN

Cartridge • Strip • Tubular • Immersion Electric Heaters • Soldering and Branding Irons
Solder and Glue Pots

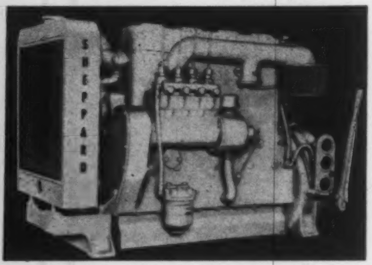
VULCAN ELECTRIC COMPANY
Danvers 6, Mass.

Please send me your catalog and price information on Vulcan-Electric Heaters. I am especially interested in (check)

☐ Tubular
☐ Immersion
☐ Other
☐ Finned
☐ Cartridge
☐ Strip

Name & Title ______
Company ______
Street & No. ______
City & State ______

Circle 492 on Page 19



bearings between each throw and at both ends of crankshaft, full pressure lubrication, and 22:1 compression ratio. Both models require less space to install than a gasoline engine of equal horsepower. **Sheppard Diesels,** Hanover, Pa. E

Circle 637 on Page 19

Pocket-Plate Batteries

for floating or standby duty

P-Series nickel-iron and nickel-cadmium pocket-plate batteries, for floating or standby duty, have sintered-iron negative plates which allow higher and flatter discharge voltages and fewer cells or smaller capacities for many standard applications. Fitted into crates or trays, they have nominal capacity based on a 5-hr discharge rate of from 4 to 500 amp hr. Batteries are unaffected by accidental short circuits, charge easily on trickle, float, normal, or high-rate charge. They can be stored indefinitely, either charged or discharged, and give off no noxious or corrosive fumes. **Gulton Industries Inc.,** 212 Durham Ave., Metuchen, N. J. D

Circle 638 on Page 19

Temperature Control

is available without enclosure

Type E65N sensitive, indicating remote-bulb temperature control is available without enclosure so that it can be incorporated or designed into equipment. It is suited for applications where accuracy and size are important, but where wide range is not. Standard models provide a variety of ranges between −50 and 150 F. Design provides setting and indications on a single scale, with

OVER 3000 HYDRAULIC EQUIPMENT USERS CONTRIBUTED THEIR EXPERIENCE IN THE PRODUCTION OF THE BRIGGS HYDRAULIC FLUID FILTER MANUAL.

It's jam-packed with practical facts taken right out of large and small shops all over the country. If you have problems . . you'll no doubt find your answers within these pages.

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PICTURED HERE is Briggs new "In-Line" 0 - 5000 psi Hydraulic Fluid Filter.

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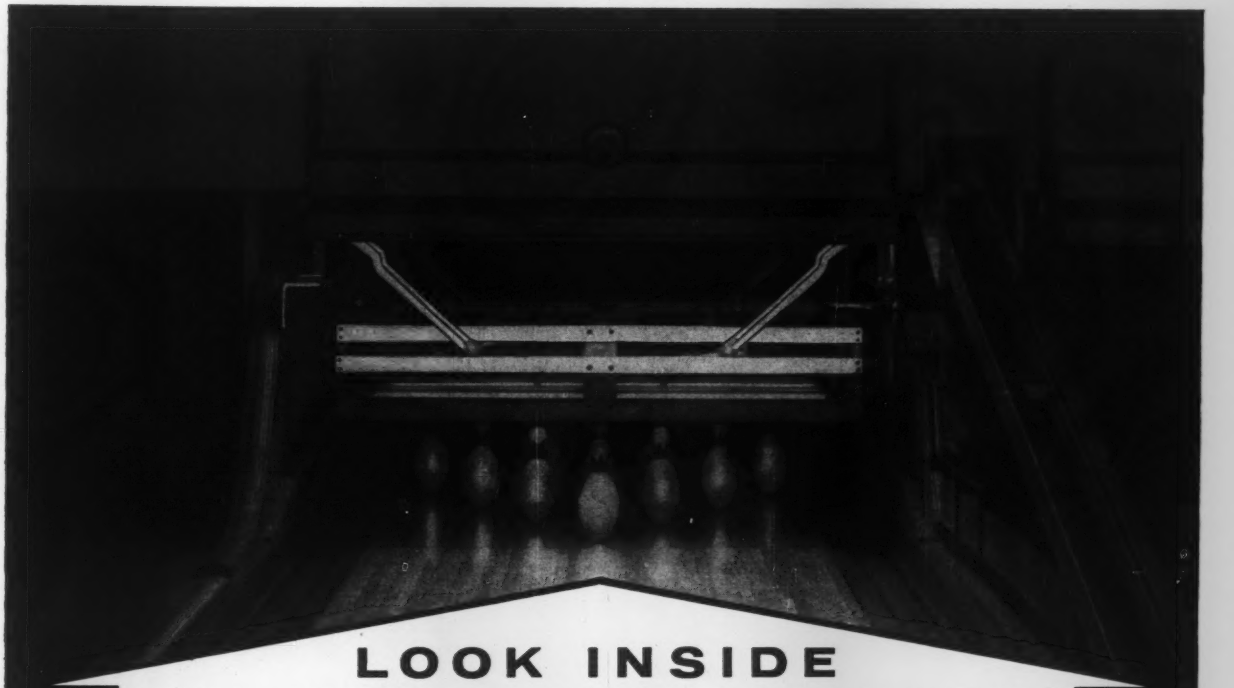
PIONEERS IN MODERN OIL FILTRATION

HYDRAULIC FLUID FILTERS
AIR/GAS LINE FILTERS
FILTER/SEPARATORS

PRODUCT OF BOWSER RESEARCH

THE BRIGGS FILTRATION COMPANY, DEPT. 259, WASHINGTON 16, D. C.
Please send without obligation ( ) HYDRAULIC MANUAL ( ) COMPRESSED AIR/GAS LINE LITERATURE ( ) FILTER/SEPARATOR INFORMATION
Name . . . .
Company . . . .
Address . . . .

Circle 493 on Page 19



LOOK INSIDE

the Sherman Pin Setter and you will find those smooth-operating, trouble-free

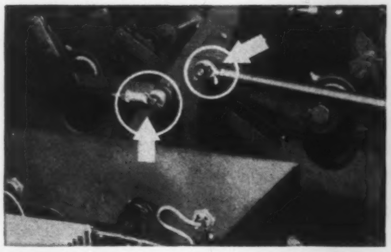
HEIM *Unibal®* ROD ENDS

Bowlers like duckpins at all hours of the day — times when pinboys are not always available. The Sherman Pin Spotter is an automatic device for setting the pins on their spots, sweeping the alley clear of deadwood, replacing remaining pins for next shot, and returning balls for next frame. These pin setters, presently made by Crompton & Knowles Corp., must be ready to operate at all times at the push of a button.

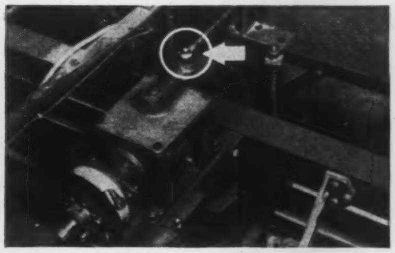
Photos taken at
Johnson's Bowling Academy,
Hamden, Conn.

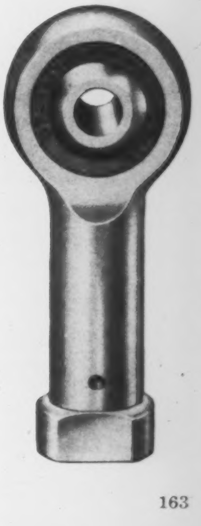
HEIM UNIBAL ROD ENDS contribute trouble-free dependability to the push-pull rods on the distributor table drive assembly, and carry the full thrust load of the sweep drive assembly (the swinging arm which sweeps the alley clear of deadwood).

Distributor table drive assembly.



Sweep drive assembly.





If you could look inside any equipment where power/motion is being transmitted at varying angles, you would find the Heim Unibal being used in more and more applications. It is the original Spherical Bearing developed, engineered, and manufactured by The Heim Company for over fifteen years.

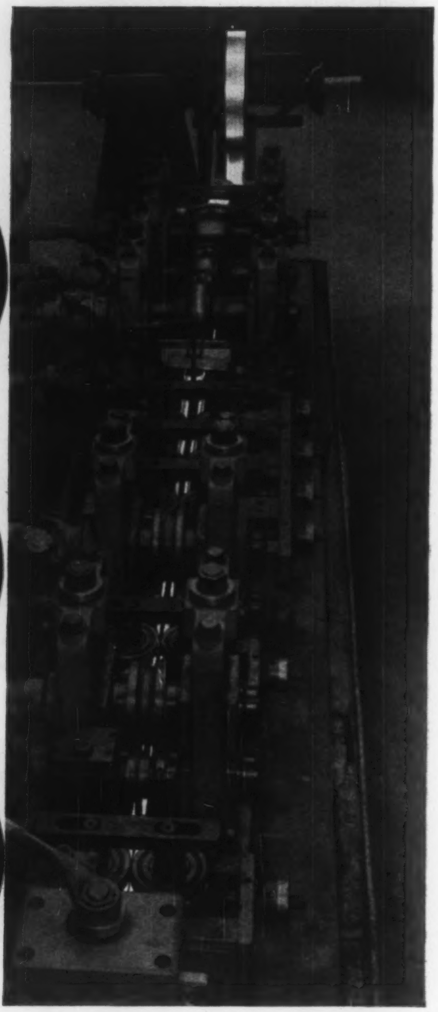
Load ratings, specifications, and sizes are all shown in the complete catalog of Heim bearings.
Write for copy, and for any special engineering data.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

Circle 494 on Page 19

STAINLESS
STEEL
PIPE &
TUBING



Warehouse Stocks Backed By Production Capacity

Damascus is a completely equipped, modern plant, able to offer stainless steel tubing in a wide range of standard A.I.S.I. analyses plus special alloy grades.

Prompt mill deliveries are possible from mill inventories, and large stocks of stainless strip on hand usually permit us to complete rush orders within a few days.

Supplementing our fast mill service are well-stocked warehouses of pipe and tubing conveniently located in major industrial areas. For prompt *local* service and immediate delivery of Damascus tubing, get in touch with your local Steel Service Center.

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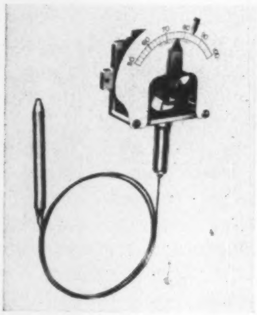
DAMASCUS TUBE COMPANY
STAINLESS STEEL TUBING AND PIPE
GREENVILLE, PENNSYLVANIA

FORMED STEEL TUBE INSTITUTE

Circle 495 on Page 19

the two pointers visible against face of dial. Unit has a white aluminum dial on a die-cast aluminum base. Thermal system consists of a brass bellows housing and copper bulb and capillary; stainless steel is also available. Several types of switches are available, including normally open, normally closed, and double throw. Ratings are 15 amp 115/230 v ac, and 20 amp 115/230 v ac. **United Electric Controls Co.**, 79 School St., Watertown, Mass. B



Circle 639 on Page 19

Indicator Lamp

for use in
transistor circuits

GE-344 incandescent lamp is for use in transistor circuits and other low-current applications. Lamp is bright enough to be seen lighted under 100 ft-c of ambient illumination. It is rated at 10 v, 15 amp, has life over 5000 hr, and bulb measures only 7/32 in. diam. **Miniature Lamp Dept., General Electric Co.**, Nela Park, Cleveland 12, Ohio. F

Circle 640 on Page 19

Motorized Gear Units

reducers are powered by
1 to 75-hp motors

Line-A-Spede drives are gear reducers powered by standard Nema-frame motors mounted on a shelf

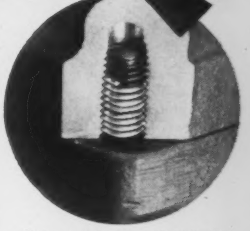
even in
roughest service...

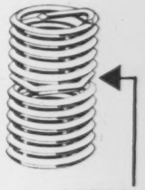
HELI-COIL®

SCREW-LOCK* INSERTS
hold fasteners tight!

Designed for greater speed, safety and economy, Chicago Pneumatic Impact Wrenches exert tremendous tightening and loosening power, resist severe shock loads and rough on-the-job use.

A key feature of their construction is the use of *Heli-Coil* Screw-LOCK Inserts which lock screws within the tapped holes at vital connections. No heavy, protruding lock-nuts are required, no lock-washers. No costly, time consuming lock-wiring. And security? *Heli-Coil* Screw-LOCK Inserts meet Government specs for locking torque and vibration. The wrench is made of aluminum alloy for lightness and ease of handling, but thread stripping in this light metal is eliminated by the stainless steel Screw-LOCK Inserts.


Cutaway showing *Heli-Coil* Screw-LOCK Insert in flange seat of Chicago Pneumatic Impact Wrench.



HELI-COIL Screw-LOCK Inserts

- positively lock screws against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling, seizing
- eliminate need for lock-nuts, lock-wiring, other supplementary locking devices
- offer high re-useability on repeated disassembly and reassembly

Screw-LOCK Inserts are available in a complete range of sizes, including the new miniature 4-40. For more information on how to make your product lighter, tighter, more compact or less costly, write

HELI-COIL CORPORATION
Shelter Rock Lane, Danbury, Connecticut
A DIVISION OF TOPP INDUSTRIES, INC.

*Pat. Applied For

HELI-COIL CORPORATION
507 Shelter Rock Lane, Danbury, Conn.

☐ Send me complete design data on *Heli-Coil* Screw-LOCK Inserts.

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ADDRESS___________________________

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IN CANADA: W. R. WATKINS CO., LTD., 41 Kipling Ave. S., Toronto 18, Ont.

Circle 496 on Page 19

STEEL from Wheelock, Lovejoy BULLETIN

W-L CHICAGO Now in an ideal position to supply HY-TEN "M" Temper in large forged flats up to 6 x 22", rounds to 18" and squares to 17½". Also "B" No. 3-X in large forged flats to 6 x 13", rounds to 18" and squares to 16". Alloy forgings a specialty.

W-L DETROIT The new, larger warehouse and office here have greatly speeded up delivery on our orders and services in this area. Have a good stock of A-8620 on hand as well as all HY-TEN grades.

W-L CLEVELAND The rolls for this Vaughn Four-Roll Continuous Pointer are fabricated from HY-TEN "M" Temper, nickel-chromium-molybdenum oil hardening steel. This Pointer, largest of its type in the world, can point rods ranging from ½" to 1¼" dia. HY-TEN "M" was selected by the machine manufacturer because it can be quenched and tempered to high hardness levels while retaining considerably greater toughness than would be possible with most other steels.

W-L CINCINNATI Another new and larger warehouse recently opened here. Same-day service on all sizes, shapes and grades of HY-TEN, plus our usual help on metallurgical problems.

W-L HILLSIDE, N. J. This W-L warehouse has an excellent stock of HY-TEN "B" No. 3-X in rounds, flats and squares. Same-day delivery is promised. Many of the larger sizes of forged rounds are rough turned.

W-L CAMBRIDGE HY-TEN "B" No. 2 is still a great favorite in New England for parts requiring medium duty and high quality at a reasonable price. Our research and development assure better HY-TEN specials — "the standard alloy steels of tomorrow."

W-L BUFFALO New HY-TEN "B" No. 3X-40 now available here in rounds ½" to 8¼" and hexagons 1¼" to 2¾", heat treated to 300 Brinell. Machines as easily as heat-treated 4140 leaded, but less expensive. Suitable for flame or induction hardening — tough and shock resistant.

Write our Cambridge office today for your *free* Wheelock, Lovejoy Data Sheets. They'll give you complete technical information on grades, applications, physical properties, tests, heat treating, etc.

WHEELOCK, LOVEJOY & COMPANY, INC.
133 Sidney Street, Cambridge 39, Mass.

AMERICAN STEEL WAREHOUSE ASS'N.

AGENTS: Southern Engineering Company, Charlotte, N. C.; Sanderson-Newbould, Ltd., Montreal & Toronto

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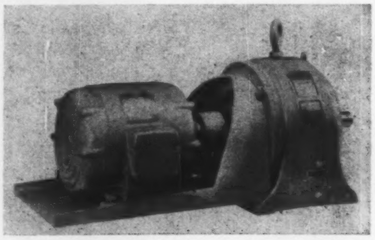


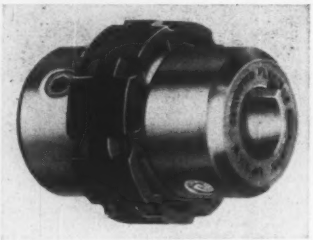
attached to reducer. Double, triple, and quadruple reduction gear units, with ratios to 1487.1, are available for motor ratings of 1 to 75 hp. Units are designed for installations where down time is critical. Motors can be replaced rapidly by disconnecting coupling between motor and reducer. Units are available for horizontal, vertical, flange, incline, sidewall, or ceiling mounting. Backstop to prevent reversed rotation is available. **Louis Allis Co.,** Dept. P, 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 641 on Page 19

Flexible Coupling

is rated for 15 hp at 1750 rpm

No. 5R flexible coupling is for shaft diameters from ¾ to 1⅝ in. Unit is rated for 15 hp maximum at 1750 rpm. **Certified Flexible Couplings Inc.,** 37 N. Bond St., Mt. Vernon, N. Y. D



Circle 642 on Page 19

Electrical Steel

for use in high-frequency equipment

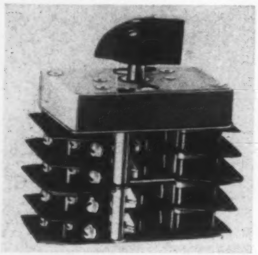
New electrical steel, called 0.004-in. Silectron Special Grade strip, is for use in high-frequency equipment where high permeability and low exciting current are essential at high inductions. It permits reduction of size and weight of equipment without sacrificing electrical performance. Material is a C-10 coated, cold-rolled oriented strip with best magnetic properties parallel to rolling direction. **Allegheny Ludlum Steel Corp.**, Henry W. Oliver Bldg., Pittsburgh 22, Pa. F

Circle 643 on Page 19

Rotary Selector Switches

provide variety of sequences

Series 20AS compact rotary selector switches switch high currents in a variety of sequences. Assemblies, built up from individual high-precision switches, are grouped in two rows on either side of camshaft. Each basic switch is single pole double throw, and has its own operating cam, providing a variety of operating sequences. Assemblies are available with four to twenty switching units. Electrical rating is 10 amp, 125, 250, or 460 v ac; ½ amp, 125 v dc; ¼ amp, 250 v dc per basic switch. **Micro Switch, Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill. K

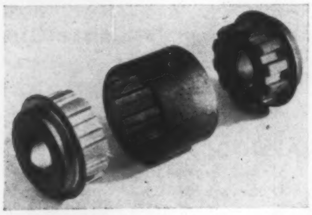


Circle 644 on Page 19

Flexible Coupling

for power-transmission systems

New flexible coupling absorbs load pulsations and shocks in power-transmission systems. Coupling consists of a heat and oil-resistant neoprene sleeve with axially-molded teeth and two metal end-fittings with grooves that mate with teeth of sleeve. Length of unit can be varied by increasing length of sleeve section. Neoprene sleeves are reinforced with high-capacity textile



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Make Norgren the most complete line available!

For ¼″ through 1½″ Pipe Sizes
Up to 300° F Operating Temperature
Removable Bowl
Norgren
5 to 250 psi Operating Pressure
Automatic or Manual Drain
Highly Efficient Water Removal

REDUCE COSTLY WEAR ON YOUR AIR EQUIPMENT

...with Norgren Air Line Filters

- **Now, 98 Models to choose from**—¼″, ⅜″, ½″, ¾″, 1″, 1¼″ and 1½″.
- **Abrasive Solids and Corrosive Liquids** are removed from air lines, reducing equipment wear, repair and replacement costs.
- **Transparent or Metal Bowls**
- **Choice of 4 Filter Elements**—74, 64 or 25 micron...5 micron available in some sizes.
- **Automatic or Manual Drain**

For complete information about Norgren Air Line Filters, call your nearby Norgren Representative listed in your telephone directory—or **Write For Descriptive Literature**

If it's Norgren...It's Dependable.

C. A. NORGREN CO.

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Circle 498 on Page 19

NEWS FROM FLEXONICS

BELLOWS APPLICATION ENGINEERING

One of a series of reports on more effective use of metallic bellows in new or unusual applications.

BELLOWS TYPE VACUUM VALVES

How Westinghouse uses Flexon Bellows in the vacuum system of Ignitron Rectifiers

The Ignitron Rectifier manufactured by Westinghouse Electric Corporation is an ingenious utilization of the rectifying property of the mercury vapor arc. This development has not only extended the scope of mercury arc rectifiers to the lower voltage range, but has provided new high standards of performance.

Maintenance of Vacuum Is Essential

It is essential that the Ignitron be substantially free from gases other than mercury vapor. Westinghouse provides the means of evacuating the tube with an integral vacuum system. Vacuum is maintained by a continuously operated mercury vapor vacuum pump capable of evacuating a vessel to the order of a fraction of a micron. The mercury vapor vacuum pump discharges to an interstage reservoir which in turn is exhausted by a rotary vacuum pump.

Two bellows type vacuum valves are used in the system. In both, Flexon stainless steel bellows are employed as shaft seals.

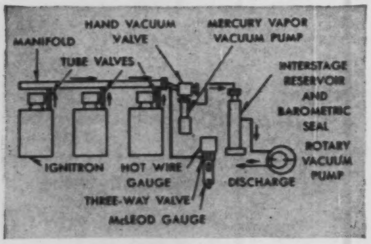


Fig. 1 Schematic view of vacuum system for Ignitron Rectifiers.

The Hand Operated Vacuum Valve

The bellows type vacuum valve is designed especially for use between the rectifier vacuum manifold and the mercury vapor vacuum pump. It consists of a machined steel bar, one end of which is made to form a vacuum gasket seat and also hold the movable mechanism of the valve. The other end of the valve body is drilled to form the valve intake. The outlet is a machined hole in the side of the valve body.

The bellows assembly consists of a stainless steel bellows welded to the bolted-on portion of the valve and also to a steel bar with flange at the lower end of the bellows. A rubber gasket is bolted in place to the flange end of the steel bar.

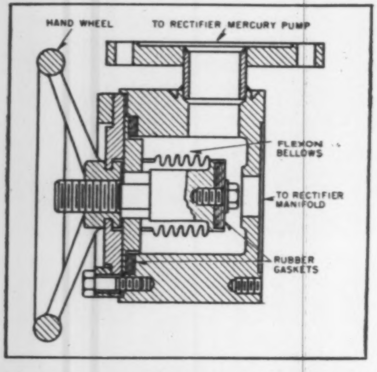


Fig. 2 Cross section view of the bellows type vacuum valve used between the rectifier and the pump.

The Three-Way Vacuum Gauge Valve

A three-way bellows type valve is employed in connections to the vacuum gauges. It is similar in design and construction to the valve used in the vacuum pump line except that it is provided with an additional port.

Valve Quality and Life Depends on Bellows

In devices such as these, the ability of the valves to hold the required vacuum level depends on the leak tightness of the bellows. The life of the valve depends on the bellows' resistance to fatigue developed in opening and closing the valves. In the face of these potential dangers, bellows quality and dependability are essential.

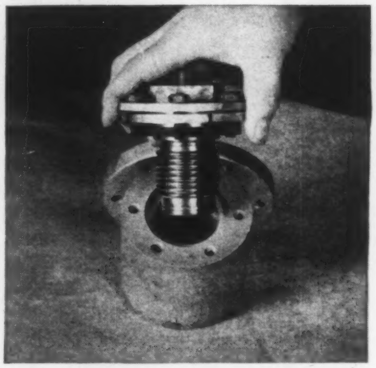


Fig. 3 Valve mechanism being lifted out of the valve body.

Why Flexon Bellows Are Used

Westinghouse uses Flexon Bellows Assemblies in the Ignitron Rectifiers to take advantage of Flexonics Corporation's facilities and bellows manufacturing know-how. Flexonics' application engineers are cost conscious, skilled in recommending the bellows or bellows assemblies that provide the performance required by the device at the lowest price consistent with these requirements.

Engineering Assistance

The Flexonics Application Engineering Staff will be pleased to assist you in your bellows application problems. For specific recommendations send an outline of your requirements. For your bellows reference file, write for the Flexon Bellows Design Guide.

Flexonics Corporation

BELLOWS DIVISION
B-46

1339 S. THIRD AVENUE • MAYWOOD, ILLINOIS
In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario
Also Manufacturers of Rubber and Metal Hose Assemblies • Expansion Joints • Aircraft Components

Circle 499 on Page 19

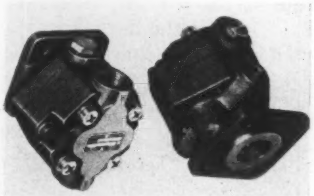
fibers in larger size couplings. **United States Rubber Co.**, Rockefeller Center, New York, N. Y. C

Circle 645 on Page 19

Hydraulic Pumps

are low-volume,
high-pressure units

Eight low-volume, gear-type hydraulic pumps are designed for high-pressure needs with low power consumption. They have built-in relief and check valves to eliminate need for additional plumbing. Pumps are available with tang or keyed drive shaft. Capacities range from 1/2 to 3.7 gpm, and pumps can be operated at speeds to 2600 rpm. **Hydraulics Div., Webster Electric Co.**, 1900 Clark St., Racine, Wis. K

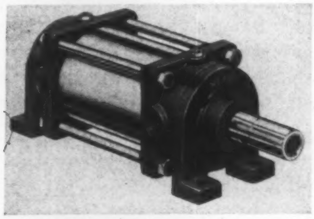


Circle 646 on Page 19

Air Cylinders

for pressures to 250 psi

Double-acting air cylinders are available in four models with four sizes for each model. They are horizontal, vertical, pivot, or face mounted, and bores are 1 1/2, 2 1/2, 3 1/4, and 4 in. Basic cylinders are alike, but mountings are interchangeable. All models have internal cushioning at both ends, but can be converted to non-cushioned units by removing cushion-adjustment screws. Ram bearing surface is 3:1 of cast Meehanite. Cylinders are for working pressure of 250 psi. **Mead Specialties Co.**, AC-25, 4114 N. Knox Ave., Chicago 41, Ill. J



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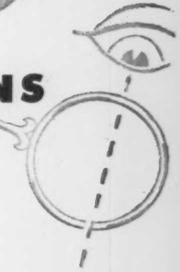
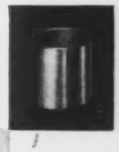
time to re-examine

BEARING APPLICATIONS

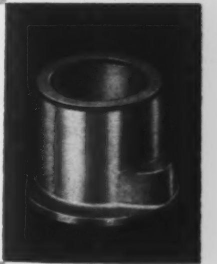


Striking cost reductions in bearing applications in many mechanical products are made possible by the use of Bunting Sintered Powdered Metal Bearings and parts.

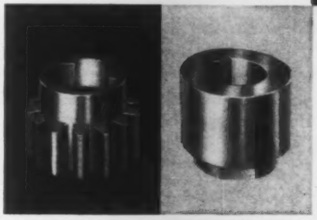
Bunting engineering counsel can guide you in the selection of designs and alloys that will provide bearings of exactly the type, design and material that will fully meet both cost and functional requirements, whether the material be Cast Bronze or Sintered Metal.



A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command, comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.



Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.



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OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

Circle 500 on Page 19

Don't Pay for
Precision You Don't Need

RMB Filmoseal Bearings available in low-cost ABEC-1 as well as ABEC-5 tolerances.

Big news in the miniature bearing field! RMB's famous Filmoseal Bearings—the only sealed miniature bearings—are now made to low-cost ABEC-1 as well as ABEC-5 tolerances. This means designers can use these advanced design bearings even in those slightly less demanding applications where cost is a primary consideration. Designers can take advantage of such features as:

1. Stainless-steel construction *throughout.*
2. Lubricant retention at *high temperatures.*
3. Non-contaminating *at all times.*
4. Two-piece ball separators for *high speeds.*

Open radial Conrad-type bearings are also available in this new grade. A wide range of sizes is available from 3/16" (0.1875") to ½" (.5000") OD including many metric sizes.

Write for your copy of the new RMB Miniature Bearings Catalog which gives full details on these as well as the entire line of quality RMB Bearings. Ask for Bulletin 62.

LANDIS & GYR, INC.
45 West 45th Street • New York 36, N. Y.

Circle 501 on Page 19

CAN YOU USE THESE FEATURES IN
VARIABLE SPEED DRIVES AND DIFFERENTIAL TRANSMISSIONS?

- **Full torque at zero speed**
- **Smoothly adjustable through zero speed**
- **Draw accuracies of .01%**
- **Shockless starts • Fully reversing**
- **Output speed ranges from 0-7000 rpm**

Consider SPECON drives, transmissions and gear boxes for your variable speed drive requirements.

Designed and produced by Stratos, the family of SPECON drives and transmissions is shown in a new free booklet — including capacity charts and output speed regulation.

Write today to: **SPECON**

Stratos Industrial Products Branch #42, Route 109, West Babylon, N.Y.
Turbo-Expanders and Compressors • Pneumatic Pressure Regulators
• SPECON Variable Speed Drives and Transmissions

The differential gearing of SPECON mechanical transmissions and electrical drives is available where gear boxes alone are needed. Special units for specific requirements are a SPECON specialty — standard sizes up to 75 hp are also available.

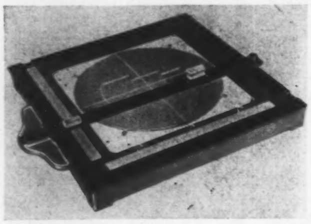
Circle 502 on Page 19

ENGINEERING DEPARTMENT EQUIPMENT

Chart Layout Board

for use with any chart layout material

New chart layout board facilitates the drawing or scribing of chart layouts up to 14 in. in diam or 11 x 14 in. rectangular. Board can be used with any chart layout material from 0.030-in. plastic to $\frac{1}{8}$-in. glass. Interchangeable scales permit direct layout of blueprint dimensions at either the same size or magnified without mathematical conversions or calculations. Board is illuminated by a neon cold light. Satin-chromed T-square has transparent hair-line index with magnifier and outboard lock to prevent movement during drawing or scribing. **Optical Gaging Products Inc.**, 26 Forbes St., Rochester, N. Y. F

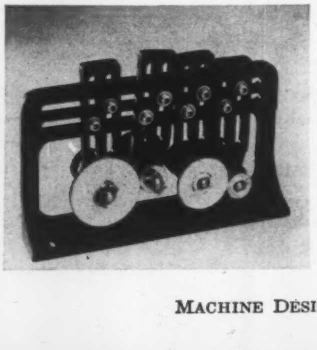


Circle 648 on Page 19

Hanger Assembly

for use in breadboarding

New hanger, with mounting centers spaced for use with most existing breadboard plates, permits assembly of a complete gear train as an integral unit. Large reductions, having several meshes, can be set up



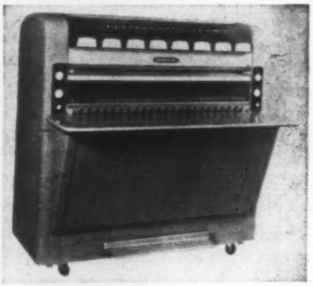
independently prior to mounting on breadboard plate. Bores are set in accordance with recommended bearing-mounting specification for precision fits. Flexibility allows for simple adjustment for low backlash. Maximum of six vertical adjustable hangers can be mounted on main frame. **Instrument Div., Sterling Precision Corp.,** 17 Matinecock Ave., Port Washington, L. I., N. Y. D

Circle 649 on Page 19

Whiteprint Machine

accommodates materials 42 in. wide of any length

Modified and improved Printmaster 810 is a whiteprint machine for the reproduction of engineering and architectural drawings, a wide variety of business forms, and other materials. It accommodates materials of any length up to 42 in. wide, and printing and developing speeds are synchronized to 40 fpm. Unit has increased visibility and redesigned brush-feed assembly. Machine requires floor space of 61 x 42 in., and is 61 in. high. **Ozalid Div., General Aniline & Film Corp.,** 14 Corliss Lane, Johnson City, N. Y. D



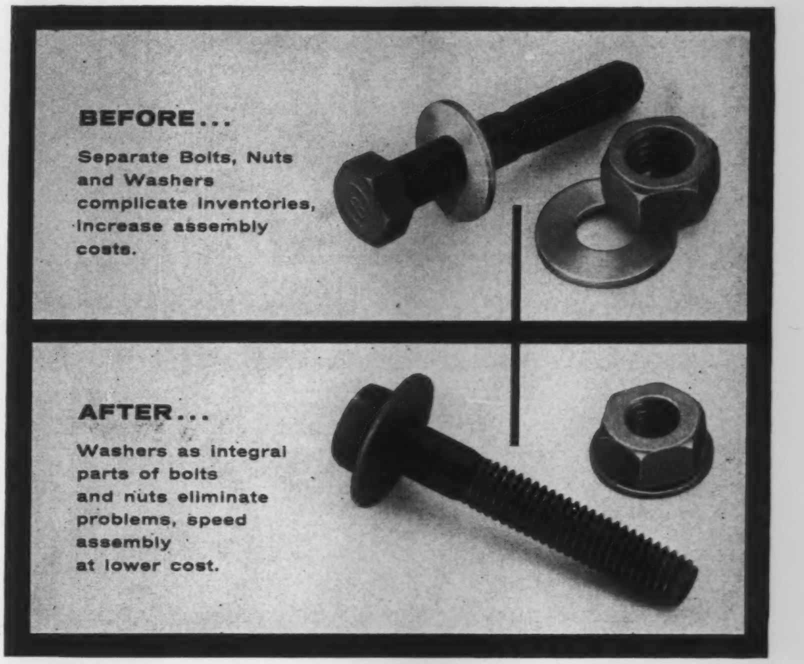
Circle 650 on Page 19

Narrow Tapes

in six new patterns

Narrow Curve-Line tapes are available in six new patterns, furnished in combinations of black on white, red on white, blue on white, green on white, and black on transparent. Width measurements are guaranteed to ±0.002 in. Tape sizes range from 1/32 to 1/16 in. wide by 648 in. long, and ⅛ to ¼ in. wide by 324 in. long. **Chart-Pak Inc.,** 1 River Rd., Leeds, Mass. B

Circle 651 on Page 19



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Separate Bolts, Nuts and Washers complicate inventories, increase assembly costs.

AFTER...

Washers as integral parts of bolts and nuts eliminate problems, speed assembly at lower cost.

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by simplifying fastener design

Here is a simple application of a basic bolt making principle which is affecting substantial savings for a number of manufacturers.

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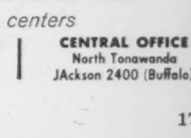
If you can use a copy, write to North Tonawanda or ask a Field Representative.



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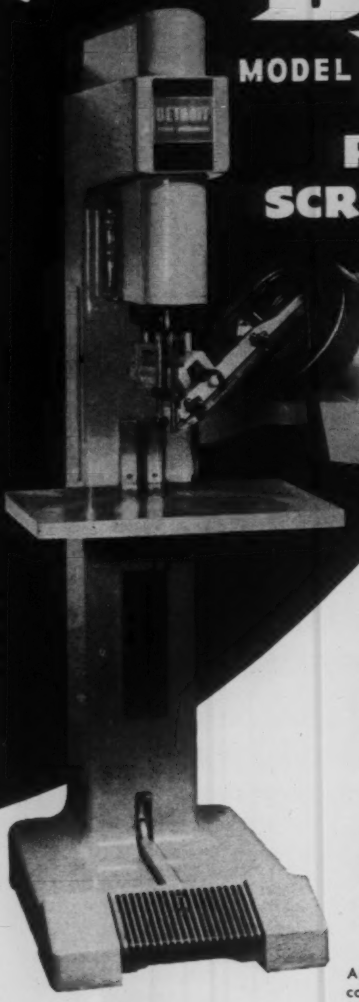

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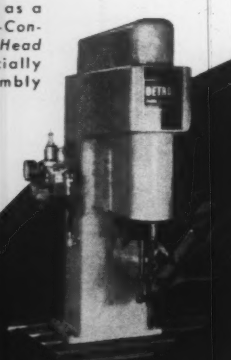

THE ENGINEER'S

Library

Recent Books

High-Speed Data Processing. *By C. C. Gotlieb and J. N. P. Hume; 338 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$9.50 per copy postpaid.*

The principles and techniques of processing data at high speeds are outlined in this book.

Data processors of all types, their functions, uses, advantages, and limitations, are discussed. Also included are a variety of examples and illustrations.

Electron-Tube Circuits, Second Edition. *By Samuel Seely, Professor and Head, Department of Electrical Engineering, Case Institute of Technology; 695 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$10.50 per copy, postpaid.*

This new edition provides a broad background in electronic circuits for application in radio and electronic engineering. It presents an analytical basis for understanding the dependence of operation or performance of the circuit on the circuit parameters, and indicates with examples the procedure for combining circuits of various types. The treatment of the principles of feedback has been expanded, and there is new information on solid-state electronics, the transistor, and the theory of transistor circuits.

Graphic Science. *By Thomas E. French, late Professor of Engineering Drawing, Ohio State University, and Charles J. Vierck, Professor of Engineering Drawing, Ohio State University; 758 pages, 7½ by 10 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$8.50 per copy postpaid.*

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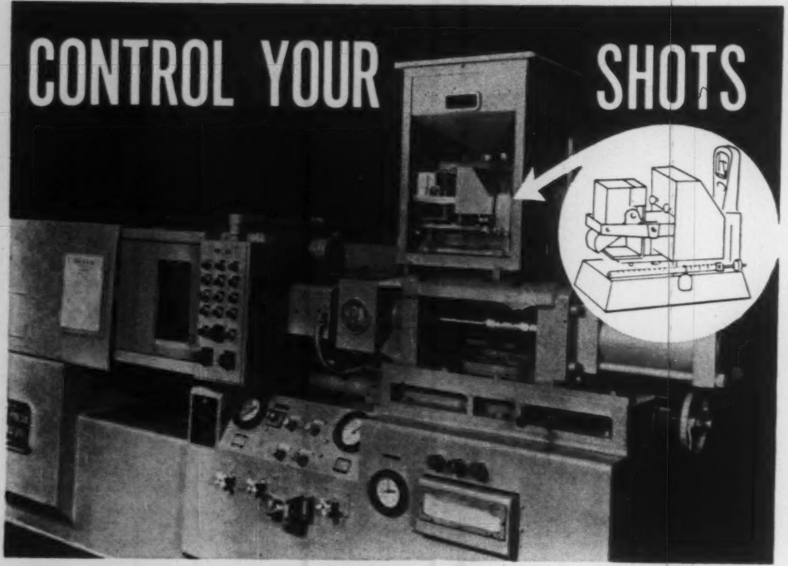

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Circle 506 on Page 19

combined in this one volume. Focus throughout is on drawing as a tool for the engineer.

Descriptive geometry, vector geometry, graphical solutions, functional scales, nomography, empirical equations, and calculus are covered.

Logical Design of Digital Computers. *By Montgomery Phister, Jr., Director of Engineering, Thompson-Ramo-Wooldridge Products Inc.; 408 pages, 6 by 9 in., clothbound; published by John Wiley and Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$10.50 per copy postpaid.*

Using synchronous-circuit components, this book describes and interprets the methods and techniques applied to problems in the design of digital computers.

Included in the topics covered are the three basic steps to design, and a detailed discussion on the circuit components themselves.

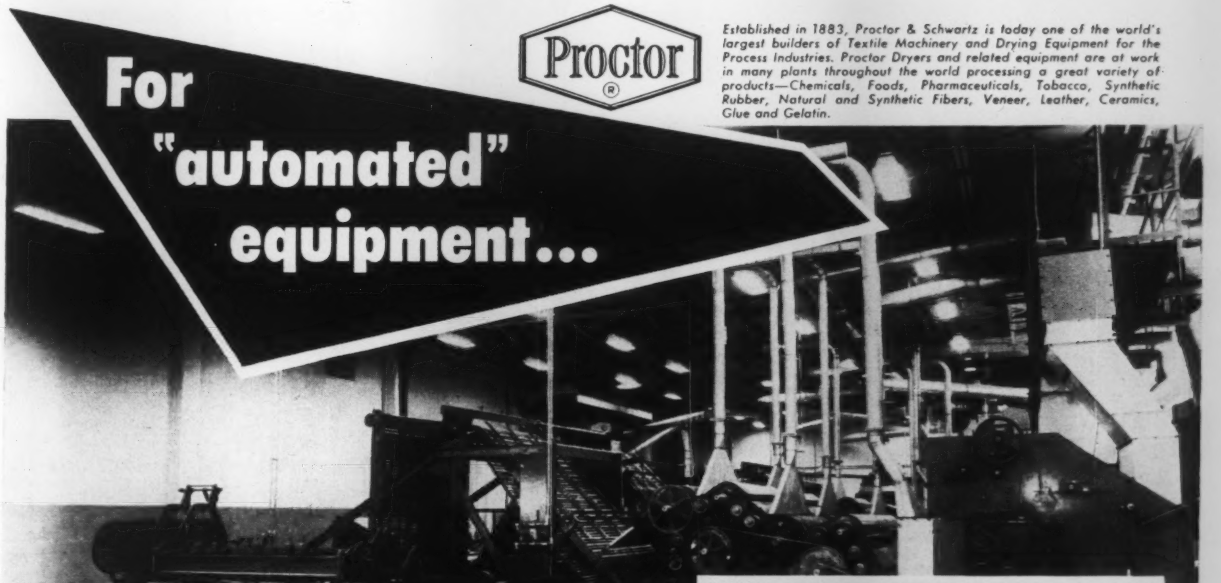
Mathematics of Physics and Modern Engineering. *By I. S. Sokolnikoff, Professor of Mathematics, and R. M. Redheffer, Associate Professor of Mathematics, University of California, Los Angeles; 810 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$9.50 per copy postpaid.*

Topics presented in this book deal with present-day problems encountered in science and technology. Some of the subjects covered include ordinary differential equations, infinite series, functions of several variables, algebra and geometry of vectors, matrices, partial differential equations, and complex variables.

New Standards

ASTM Standards on Light Metals and Alloys. *310 pages, 6 by 9 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $3.75 per copy.*

This publication presents in reference form the various ASTM methods for test, and specifications pertaining to the various forms, of aluminum, magnesium, and their alloys. Included in the volume are 41



Proctor®

Established in 1883, Proctor & Schwartz is today one of the world's largest builders of Textile Machinery and Drying Equipment for the Process Industries. Proctor Dryers and related equipment are at work in many plants throughout the world processing a great variety of products—Chemicals, Foods, Pharmaceuticals, Tobacco, Synthetic Rubber, Natural and Synthetic Fibers, Veneer, Leather, Ceramics, Glue and Gelatin.

Versatile ACIPCO Centrifugally Spun STEEL TUBES

Completely automatic batt making systems for the bedding industry have been manufactured by Proctor & Schwartz, Inc., of Philadelphia, for more than 40 years.

ACIPCO spun tubes are used as garnett rolls in one of the newest of these automatic machines, the Proctor "700" garnett. These rolls must be finely machine-slotted to receive the garnett wire in which they are clothed. After long service, worn wires may be replaced and the rolls resurfaced and remachined.

Because ACIPCO tubes are centrifugally spun, they possess a dense, homogeneous grain structure which is easier to machine. This advantage is only *one* of the reasons Proctor and Schwartz specifies ACIPCO tubes for their machines. There are many others, including the *inherent* dynamic balance and dimensional stability of ACIPCO tubes, their wide size range, and ACIPCO's complete "one source—from start to finish" facilities.

If your machines or products employ tubes of stainless steels, carbon steels, alloy irons, or special analyses as components, ACIPCO may be your best source. Call or write for complete information on ACIPCO tube applications in your field. No obligation, of course.

VERSATILE ACIPCO CENTRIFUGALLY SPUN STEEL TUBES

SIZE RANGE: Lengths up to 410″, to meet modern machinery requirements, have been produced. OD's from 2.25″ to 50″; wall thicknesses from .25″ to 4″.

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special analyses.

FURNISHED: As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.

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ACIPCO

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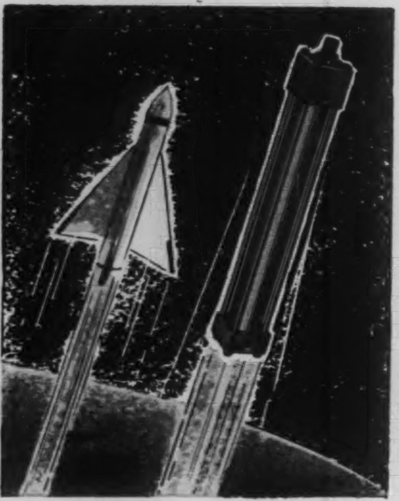
ACIPCO



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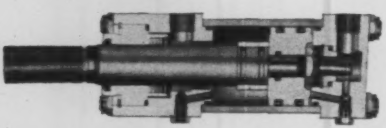

Any resemblance between a guided missile and an O-M AUTOMATION cylinder is purely coincidental. However, each stands as a symbol of progress in its own field.

In the Series RA and RH air and hydraulic cylinders O-M has incorporated many advanced features in an extremely rugged line of cylinders designed to meet automotive industry specifications for Automation cylinders. The advanced design of these cylinders makes them well suited for severe applications in all types of machinery and equipment.

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Circle 508 on Page 19

specifications and 10 general methods of tests. Among the shapes and forms covered are ingots, castings, bars, rods, wire, forgings, pipes, tubes, sheets, and plates.

Association Publications

Investment Casting Metal Specifications. *27 pages, 8½ by 11 in., loose leaf; published by and available from Investment Casting Institute, 27 East Monroe St., Chicago 3, Ill.; $1.00 per set.*

Included in this set of metal specifications for investment casting are two new ones on cast nickel-chromium stainless steel and beryllium copper.

How To Select An Air Compressor. *11 pages, 8½ by 11 in., paperbound; published by and available from Air Compressor Research Council, 27 East Monroe St., Chicago 3, Ill., $0.50 per copy.*

Contained in this booklet is information on various types of air compressors, with charts for the selection of air compressors and air cylinders to suit specific needs.

Industrial Noise Manual. *107 pages, 8½ by 11 in., paperbound; published by and available from American Industrial Hygiene Association, 14125 Prevost, Detroit 27, Mich.; $7.50 per copy.*

This manual contains information on the physical characteristics of noise, its measurement, its effect on exposed persons, and its control. Although prepared primarily for use by industrial hygienists, many of the chapters will be of interest and use to the designer.

Manufacturers' Publications

A Handbook of Electrical Discharge Machining. *Three volumes, 224 pages, 8½ by 11 in., paperbound; published by and available from Elox Corporation of Michigan, 1830 N. Stephenson Highway, Royal Oak, Mich.; $15.00 per set, $5.00 per book.*

The three volumes in this set cover Applications for Industry, Equipment and Accessories, and Theory and Applications, on electrical discharge machining.

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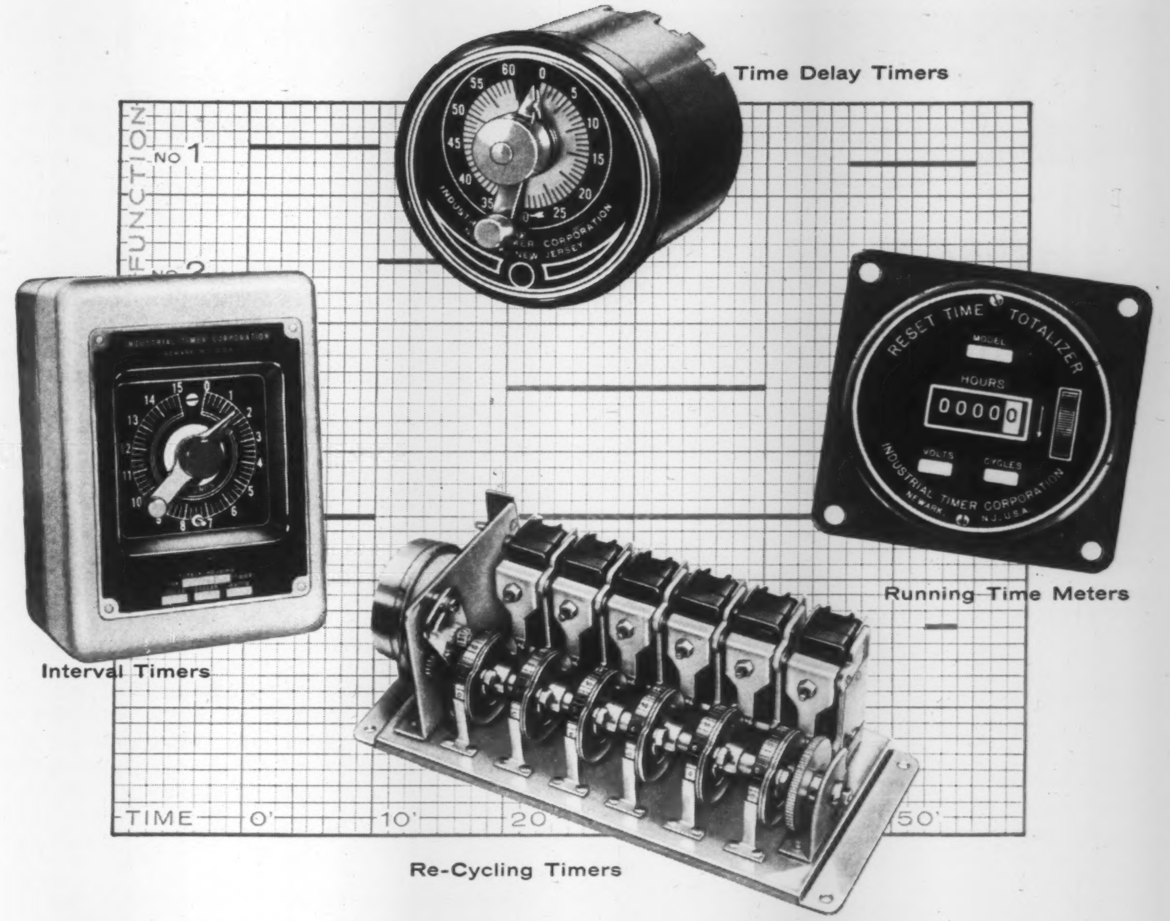
Time Delay Timers
FUNCTION
No 1
No 2
RESET TIME TOTALIZER
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10'
20
50'
Re-Cycling Timers

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If slow deliveries of timers have been delaying you in your automatic control projects, try us! True, your problem may be different and difficult indeed, for no two automatic control jobs are exactly alike. But our record in helping out in situations like these is excellent. For in this field we have a valuable background, twenty years of timer experience to be exact, that has provided us with the special knowledge required to supply our customers with the right answers.

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Timers that Control
the Pulse Beat of Industry

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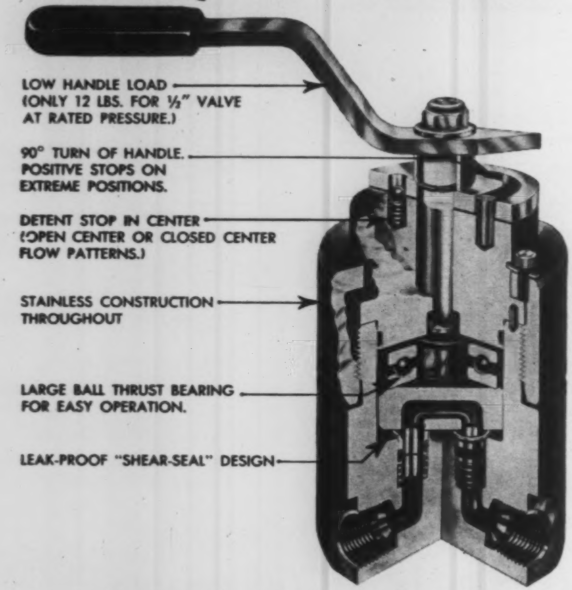
10,000 P.S.I.

4 WAY VALVE

FOR LIQUIDS OR GASES


LOW HANDLE LOAD (ONLY 12 LBS. FOR ½" VALVE AT RATED PRESSURE.)
90° TURN OF HANDLE. POSITIVE STOPS ON EXTREME POSITIONS.
DETENT STOP IN CENTER (OPEN CENTER OR CLOSED CENTER FLOW PATTERNS.)
STAINLESS CONSTRUCTION THROUGHOUT
LARGE BALL THRUST BEARING FOR EASY OPERATION.
LEAK-PROOF "SHEAR-SEAL" DESIGN

This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

Write for Catalog 58-59

CONTROL VALVE
DIVISION

barksdale valves

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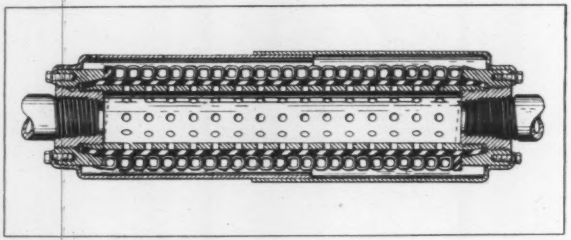
Circle 511 on Page 19

NOTEWORTHY

Patents

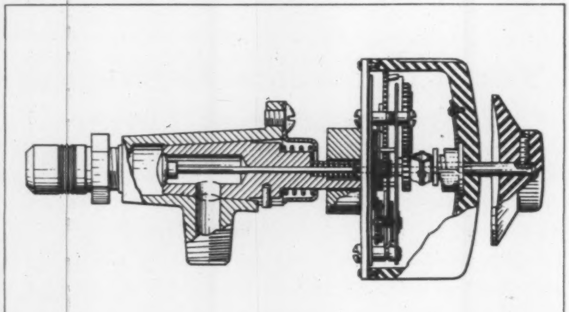
Flow Pulsation Damper

Reduction of pulsations in a fluid line is accomplished by a damper consisting essentially of three concentric tubes. The inner tube is rigid and perforated. The middle tube is continuous and flexible. The outer tube is a helical spring, closed when relaxed. Fluid under pulse flows through the perforations in the inner-tube wall and expands the middle tube. Flexing action of the middle tube is reinforced by the spring. *Patent* 2,828,771 *assigned to Westinghouse Air Brake Co., Wilmerding, Pa., by Wallace F. Poore.*



Timer-Actuated Valve

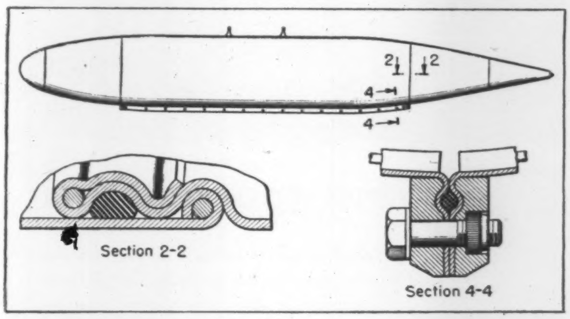
A small torque from a mechanical clock movement controls a much larger torque which closes a valve automatically at the end of a preset time interval. When the exterior timer knob is pressed in, the spring-loaded valve poppet is opened and two projections at different radii on a single part are freed from slots in a cam assembly. When the knob is turned to the desired time setting, the clock is wound and started, and the projections in the cam assembly are positioned correspondingly on two helical inclined planes. Different helix angles of the planes set up two friction torques: One to resist sliding, and a smaller one to induce sliding. The small difference to cause sliding is supplied by the clock, uniformly over the set time



interval, until the projections drop into their slots at the end of the helices and thus close the valve. *Patent 2,810,435 assigned to Robertshaw-Fulton Controls Co., Greensburg, Pa., by Roy C. Demi.*

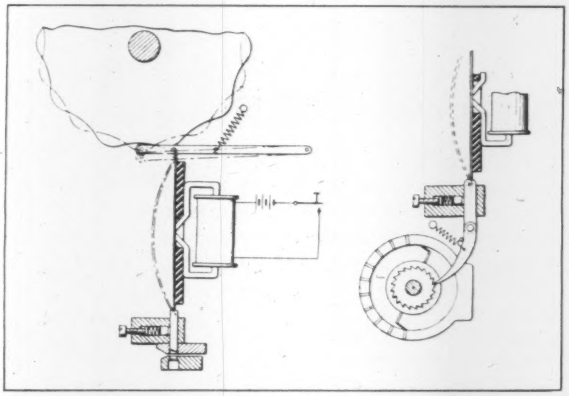
Liquid-Tight Sheet Metal Joints

Simplicity of assembly and liquid-tight seams are basic features of a cylindrical three-part sheet-metal tank. Longitudinal seam, section 4-4, carries a straight length of round gasket material between matched grooves. Mating ends of the tank sections have annular beads reinforced by wire, section 2-2. Annular corrugations in these sections receive beads and O-ring seals. As bolts are tightened in the straight seam, all three seams are closed. *Patent 2,829,793 assigned to Royal Jet Inc., Alhambra, Calif., by Billy Franklin Baumann.*



Controlled Linear-Force Transmission

In a force-transmission system, a flexible link is stiffened to enable intermittent force take-off from a periodic input, such as a cam. When the system is idling, input force is absorbed by bowing of the flexible link, which is connected at the output end to a friction-held slider. To transmit force, as for punching or counting (shown), an electromagnet is energized, causing the flexible link to be drawn against a nonmagnetic flat-plate stiffener. Force transmitted by the stiffened link is sufficient to overcome friction at the slider. *Patent 2,831,355 assigned to International Business Machines Corp., New York, by Hale G. Zimmerman.*



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Flexible
GEAR COUPLINGS

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There's a Sier-Bath Flexible Coupling for every power transmission requirement, providing you with the smallest, lightest, strongest coupling made, delivering higher rpm and greater horsepower capacity. The most wanted finished bore sizes are available for immediate delivery on order.

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Circle 512 on Page 19

TURRETABLE

Cuts cost of feeding parts to drill, tap, mill, punch, assemble

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PATHFINDER IN AIR POWER AUTOMATION

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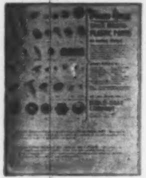
DIMCO-GRAY *Stock plastic*
KNOBS...HANDLES



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NEW HUSCO Selector Valves

Provide accurate control of Two-Line Sequence

These new precision-machined selector valves, unusually compact, space-saving, and provide instantaneous adjustment for either of the fluid lines. Important addition to the HUSCO line of hydraulic valves, cylinders, pumps and controls, the new Series 3070 Selector Valves are available in two sizes—for capacities up to 30 and 60 g.p.m.

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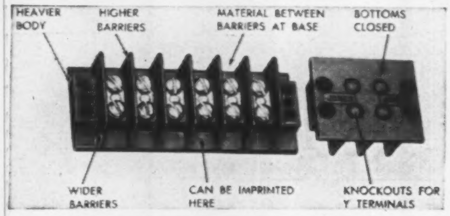

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Circle 516 on Page 19

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Circle 517 on Page 19

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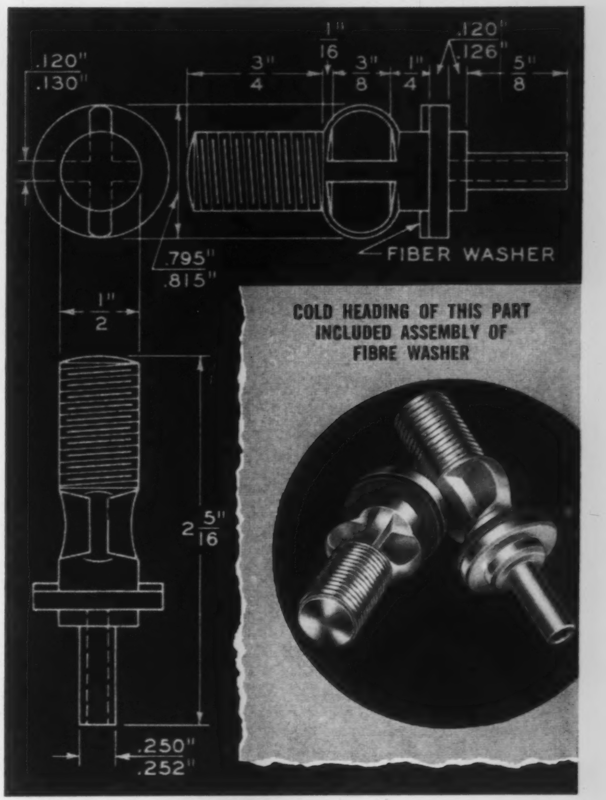

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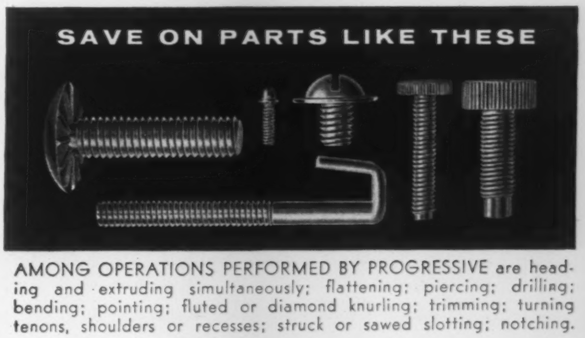

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Circle 519 on Page 19

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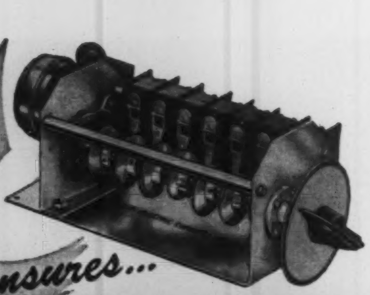

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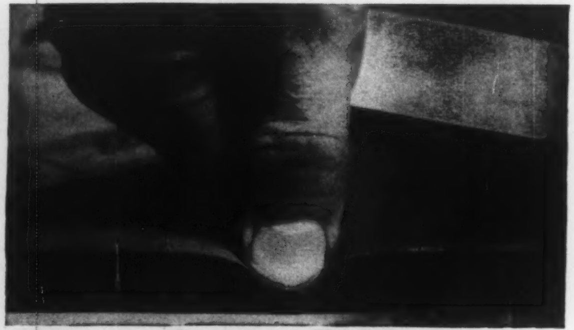

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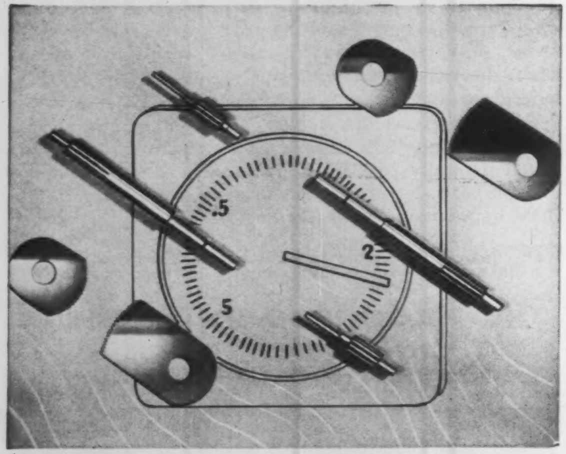

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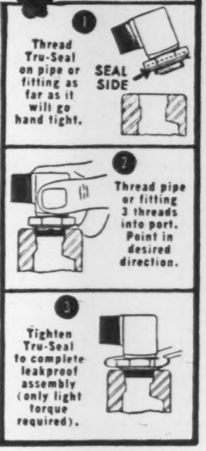

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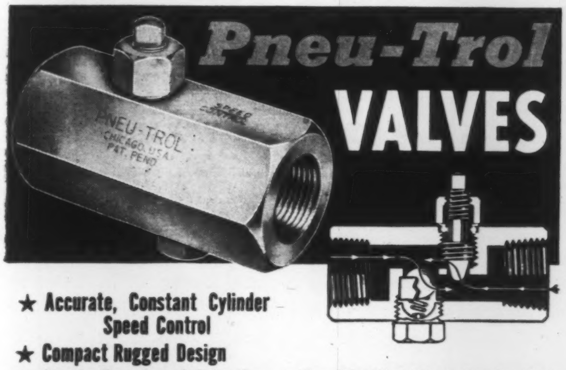
② Thread pipe or fitting 3 threads into port. Point in desired direction.

③ Tighten Tru-Seal to complete leakproof assembly (only light torque required).

Circle 523 on Page 19



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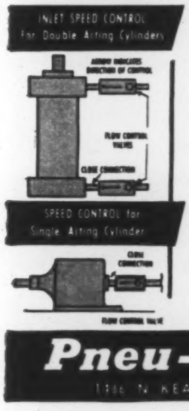
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FOR GAGING STATION

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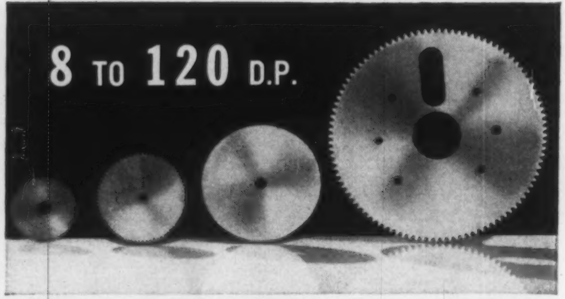

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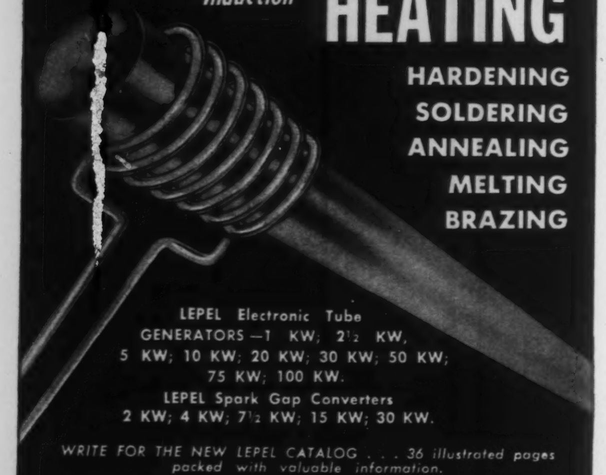
Induction **HEATING**



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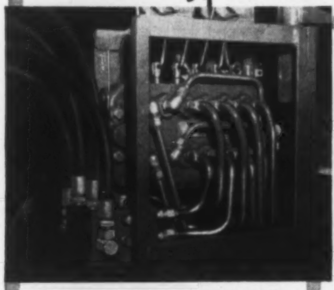

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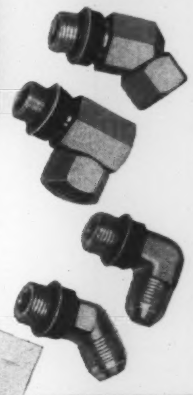

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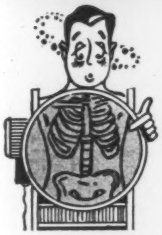

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Fig. 55A
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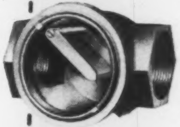

Fig. 811
Flow Indicator

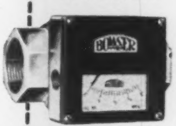

Fig. 816
Teleflow
Indicator

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SHOW WHAT GOES ON IN THE PIPE LINE

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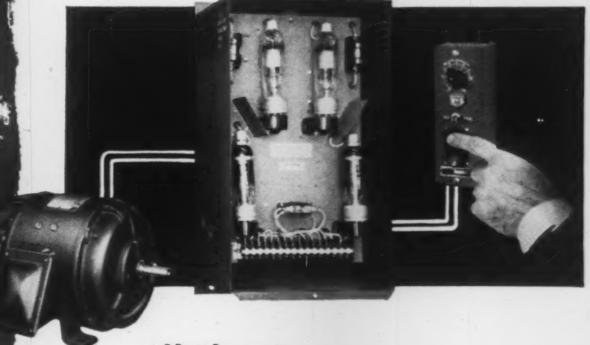
START
STOP
CHANGE DIRECTION
JOG
WIDE SPEED RANGE

New!

RELIANCE V★S Jr.



All Electric Variable Speed Drive with Finger-tip Control

The new V★S Jr. gives you instantaneous speed changes, even under load, without belts, pulleys, or gears. This Reliance Drive puts complete machine control at the operator's fingertips. All functions, jog, start, stop, reverse and speed changes are placed in a compact, remote control station.

The 8 to 1 motor speed ratio puts extra flexibility into your machinery. Speeds may be changed through this wide range as frequently as required. The motor will operate through a 100 to 1 speed range for jogging or light intermittent duty.

There's a big power cushion in the motor too . . . power for smooth speed pick up, even under heavy shock loads, and dynamic braking for fast controlled stops without shuddering or jerking.

The Reliance V★S Jr. is your answer to machinery drive problems in the ¾ to 4 horsepower range. Package construction makes installation easy; just plug it in to a single phase 220 or 440 volt a-c. line.

Write for Bulletin D-2505 for complete details. D-1554

RELIANCE R ELECTRIC

AND ENGINEERING COMPANY
Dept. 287A, CLEVELAND 17, OHIO
CANADIAN DIVISION: WELLAND, ONTARIO
Sales Offices and Distributors in principal cities

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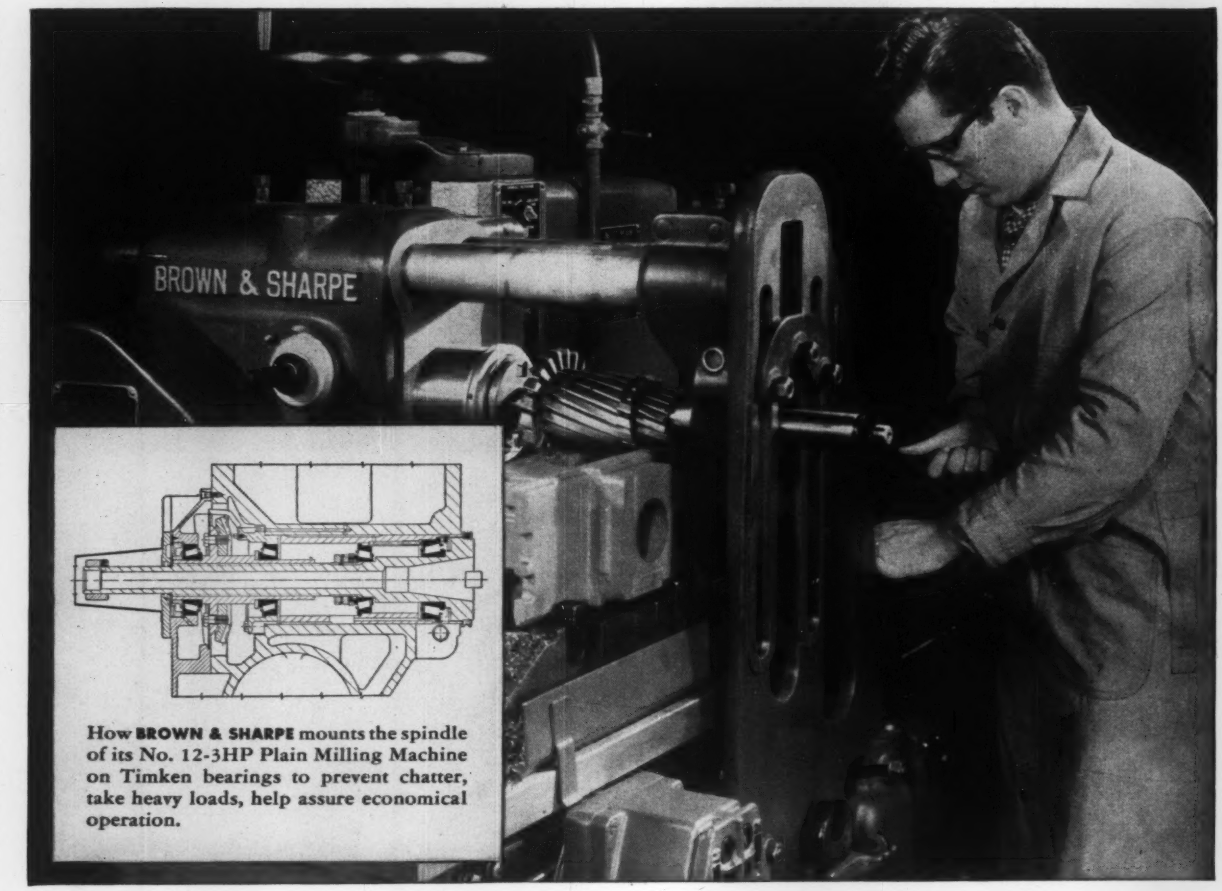

How **BROWN & SHARPE** mounts the spindle of its No. 12-3HP Plain Milling Machine on Timken bearings to prevent chatter, take heavy loads, help assure economical operation.

Climb mills both ways . . . TIMKEN® bearings prevent chatter in heavy cutting

TO make heavy cuts without chatter, Brown & Sharpe mounts the spindle of its No. 12-3HP Plain Milling Machine on two Timken® tapered roller bearings. For smooth power transmission, they use four Timken bearings in the bevel gear drive to the spindle. And to take climb milling's pulsating loads, two Timken bearings are used in the feed screw drive. Result—production milling is fast and accurate. Here's why.

• SPINDLE RIGIDITY MAINTAINED

Timken bearings hold the spindle in positive alignment. Their tapered design lets them take *both* radial and thrust loads in any combination. And full line contact between rollers and races gives Timken bearings extra load-carrying capacity.

• HEAVY LOADS ABSORBED

Rollers and races on Timken bearings are case-carburized to have a hard, wear-resistant surface over a tough, shock-resistant core. They take heavy loads and come back for more.

• FRICTION VIRTUALLY ELIMINATED

Timken bearings are geometrically designed to have true rolling motion and are precision-made to live up to their design. Practically friction-free, they last longer and run smoother. And to assure complete quality control, we even make our own electric furnace fine alloy steel. No other American bearing maker does. So for your No. 1 bearing value, always specify bearings trade-marked "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF

TAPERED ROLLER BEARINGS ROLL THE LOAD

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